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INSTITUTE FOR DEFENSE ANALYSES

Defining the Attributes of a CBRN Human Response Model Findings and Conclusions

Carl A. Curling
Julia K. Burr
Lusine Danakian
Deena S. Disraelly
Margaret R. Porteus
Terri J. Walsh
Robert A. Zirkle

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About This Publication

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PREFACE

This document reports work performed by the Institute for Defense Analyses for the United States Army Office of the Surgeon General, the Defense Threat Reduction Agency Joint Science and Technology Office, and the Department of Health and Human Services Office of Public Health Emergency Medical Countermeasures in partial fulfillment of the following task orders “Review of NATO AMedP-8 *Planning Guide for the Estimation of Battle Casualties*,” “Analytic Capabilities Development,” and “Mathematical Modeling of Medical Consequence Measures” respectively. This document describes the desired attributes for the next generation of chemical, biological, radiological, and nuclear human response medical models as defined by members of the military and civilian user communities.

The authors wish to thank the reviewers, Dr. Sid Baccam, Dr. Michael Boechler, LTC Mark Bohannon, USA, Ms. Angel Fitzgerald, Mr. Steve Krall, Ms. Jennifer Olson, Dr. Erin Reichert, Dr. Katherine Wallace, Mr. Doug Schultz, and Mr. Nafis Upshur, for their careful review of this document, and Ms. Shelley Smith who edited and produced this document.

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EXECUTIVE SUMMARY

This paper describes the results of a study to determine the attributes of chemical, biological, radiological, and nuclear (CBRN) human response models desired by three user communities: the US Department of Defense (DoD), US civilian government organizations, and the North Atlantic Treaty Organization (NATO). The purpose of this study was to develop an understanding of the attributes required for a coordinated CBRN human response model[1] that could be used by all three of these communities. Additionally, this study sought to identify areas where community views continue to diverge, by choice or necessity; provide an opportunity for communication among the various members of the military and civilian communities; and consider the potential implementation of alternate human response methodologies within one or more tools.

This study was jointly sponsored by the Defense Threat Reduction Agency (DTRA), the US Department of Health and Human Services (HHS), and the US Army Office of the Surgeon General (OTSG) in its role as the US representative to the NATO CBRN Medical Working Group. Each of this study's sponsoring organizations—the Joint Science and Technology Office (JSTO) of DTRA, the Biomedical Advanced Research and Development Authority (BARDA) within the Office of the Assistant Secretary for Preparedness and Response (ASPR) in HHS, and OTSG—had previously begun independent efforts to define the attributes of human response models required to support their organizational responsibilities. Each organization also came to recognize the potential value inherent in developing a coordinated human response model for use across the military and government. As a result, to facilitate their understanding of the user communities' requirements for such a model, these organizations tasked IDA to define a set of model attributes desired across the three communities.

In order to determine these desired model attributes, IDA interviewed 167 personnel from more than 60 military and civilian agencies, representing both current and potential users of CBRN human response models. Participating organizations included the Joint Staff and Service and Combatant Commanders' staffs, numerous military and civilian research and training

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1 A human response model, also known as a casualty estimation model, is usually one component of a larger suite of models. For our purposes, the human response model is used to estimate the status over time of personnel exposed to some event involving CBRN agents (or influenza). The model estimates the number of people who may be expected to require medical treatment, as well as the number of anticipated fatalities due to the insult.

institutes, as well as numerous federal, state, and local civilian agencies. Participants answered questions addressing several points pertaining to human response models and casualty estimation tools. These points fell into four broad categories:

- Users and Uses — addresses the scope of needs and questions that CBRN human response models are expected to cover;
- Inputs — prescribes what information should be used as model inputs;
- Output, Time, and Methodologies — describe significant attributes of the CBRN Human Response models;
- Tool and Application — while not dealing directly with the models themselves, describe oft-raised concerns of users regarding the applications that implement the model.

While a number of organizations across all levels of the military operation, military support, and civilian communities were interviewed during the course of this study, they represent only a small segment of the overall user community. Still, across these groups some important points of consensus were reached. For example, interviewees generally agreed that models could serve multiple functions including planning, training, response, and resource estimation. They agreed that the spectrum of CBRN agents and the applicable exposure routes should be included in the human response models. With regards to modeling populations, they agreed that a wide variety of population sizes, types, and variance might need to be measured; they also agreed that certain demographics should be included – for example, age, health status, and gender – as data existed pertaining to the human response model. Further, interviewees agreed that models should output the estimated number of casualties and fatalities over time. Users agreed that casualties should be further differentiated by type, severity, signs and symptoms, or systemic effects—although not all users agree on the appropriate differentiation—and that there should be some method for generating user-defined casualty levels. Interviewees also agreed that both inputs and outputs must be expressed in terms of time and that time intervals should be selected as applicable to the agent or event being modeled. Finally, while interviewees were not always familiar with the methodologies being employed, they did agree that methodologies should be selected that would be applicable, credible, scientifically defensible, and thoroughly documented.

These areas of consensus became the basis for compiling the initial lists of human response modeling functions. These modeling functions represent the attributes described by the user communities, as well as the additional variables, factors, and functions that may be necessary to implement the desired estimation process in a suite of human response models. These lists may be described as overarching attributes of a human response model; attributes

external to, but impacting, the human response model; attributes specific to the capabilities of a tool or application of the model; and attributes specific to chemical agents, biological agents, radiological exposures, and nuclear fission/fusion explosions.

The resulting lists of human response modeling functions, while of interest, represent only an intermediate step in the overall process. Next, subject matter experts from both the military and civilian threat evaluation communities need to assign priorities to the identified agents. A second prioritization, to be conducted by additional military and civilian health community experts, should compare the identified modeling functions across the top tier of agents (e.g., top 10 agents, top 50 agents, etc.) as determined in the previous step.[2]

The resulting agent-specific functional prioritization can then be used to develop a set of tasks for the modeler or the modeling community in consultation with the model sponsors. The results of this analysis are intended to be used by the sponsors of this task (OTSG, DTRA, and HHS) as guidance for the development of new and existing CBRN human response models. Such a list will also aid in the follow-on verification, validation, and accreditation of the resulting human response model. It is not expected that every attribute identified in this study will be available in every tool or application that uses CBRN human response models. It can reasonably be expected, however, that overarching attributes that were commonly desired by all of the interviewees would be present in all of the applications, and that attributes that were specifically desired by particular users, or for particular uses, would be addressed in those particular tools designed for those users or uses.

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[2] For a description of such a process, see W.M. Christenson, et.al., *The Incubator Process: Methodology*, IDA Document-2779 (Alexandria, VA: Institute for Defense Analyses, September 2002).

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I. INTRODUCTION

This paper describes the results of a study to determine the attributes of chemical, biological, radiological, and nuclear (CBRN) human response models desired by three user communities: the US Department of Defense (DoD), US civilian government organizations, and the North Atlantic Treaty Organization (NATO). The purpose of this study was to develop an understanding of the attributes required for a coordinated CBRN human response model[3] which could be used by all three of these communities. The result of this process was the eventual understanding that the interviewees generally desired the same information outputs from the model; all the organizations interviewed wanted to know the numbers and status of casualties over time and requested that they be grouped according to type of injury or illness, severity of illness, symptoms or systemic effects, and/or performance level. This is particularly interesting because the organizations interviewed varied in both their intended uses for the output values and on the specific agents and other factors for consideration in the models.

Additional objectives of the study included identifying areas where community views continue to diverge; providing an opportunity for communication among the various members of the military and civilian communities; and considering the potential implementation of alternate human response methodologies within one or more tools.

A. STUDY SPONSORS

This study was jointly sponsored by the Defense Threat Reduction Agency (DTRA), the US Department of Health and Human Services (HHS), and the US Army Office of the Surgeon General (OTSG) in its role as the US representative to the NATO CBRN Medical Working Group (CBRNMedWG). Each of the sponsoring organizations—the Joint Science and Technology Office (JSTO) of DTRA, the Biomedical Advanced Research and Development Authority (BARDA) within the Office of the Assistant Secretary for Preparedness and Response (ASPR) in HHS, and OTSG— had begun independent efforts to define the attributes of human response models required to support their organizational responsibilities. Each office determined

[3] A human response model, also known as a casualty estimation model, is usually one component of a larger suite of models. For our purposes, the human response model is used to estimate the status over time of personnel exposed to some event involving CBRN agents (or influenza). The model estimates the number of people who may be expected to require medical treatment, as well as the number of anticipated fatalities due to the insult.

that new models were needed to address threats and exposure scenarios not currently considered by existing models, and recognized the value of that collaboration on the development of a coordinated human response model. To support the development of human response models that will be useful across the spectrum of applications, these organizations tasked IDA to define a set of model attributes as desired across the three communities.

At the time the study was initiated, JSTO's interest in model attributes was directly related to its role supporting the development of the Joint Operational Effects Federation (JOEF) as the next generation of US DoD models estimating the operational impact of CBRN agents. Throughout the developer and user communities, it was recognized that JOEF must incorporate a human response model accredited by DoD and accepted by the user community. The JOEF program established the acquisition parameters for development of a new suite of tools.

BARDA's mission is to provide "an integrated, systematic approach to the development and purchase of the necessary vaccines, drugs, therapies, and diagnostic tools for public health medical emergencies"[4] and to manage Project Bioshield, which identifies and procures medical countermeasures for CBRN agents and other emerging infectious diseases. The direction to HHS to develop a stockpile of material for national response to CBRN disasters implies the requirement for a national model representing civilian human response (versus military human response) to CBRN events that is acceptable to cities, states, and the federal government. One of BARDA's aims was to determine if a requirement exists for an alternate human response model estimating civilian casualties and fatalities or if existing models could be extended to incorporate perceived differences between military and civilian human responses.

The NATO Alliance publishes Allied Medical Publication 8, "Medical Planning Guide of NBC Battle Casualties" (AMedP-8), a document which provides estimates of casualties resulting from the use of CBRN weapons on a battlefield. While generally accepting of the current manual on the estimation of CBRN casualties, NATO members desired updated models to increase the utility of AMedP-8. Per the Nations, the new version of AMedP-8 (AMedP-8(C)) must address a wide range of military operations, for units ranging in size from squads to an Allied Task Force. NATO Allies also intended to expand the scope of the desired AMedP-8(C) to address classical CBRN warfare agents, toxic industrial chemicals and materials, radiation dispersal devices, pandemic influenza, and other emerging threats. The Office of the US Army Surgeon General (OTSG) is the custodian of AMedP-8 and is responsible for preparing AMedP-8 for review and ratification by the Nations.

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4 Department of Health and Human Services. (2007). Biomedical Advanced Research and Development Authority. *Website*. www.hhs.gov/aspr/barda/index.html. Accessed on: 13 NOV 2007.

B. STUDY PARTICIPANTS

This study used interviews of multiple agencies across the potential user community to define the desired CBRN human response model attributes. The interviewees included more than 160 personnel from more than sixty military and civilian agencies, including the Joint Staff and Service and Combatant Commanders' staffs, numerous military and civilian research and training institutes, as well as various federal, state, and local civilian agencies. Questions were selected to address several points of interest to the sponsors of this study. The first set of questions, "Users and Uses," addresses the scope of needs and questions that CBRN human response models are expected to cover. "Inputs" prescribes the information that should be used as model inputs. "Output," Time," and "Methodologies" each assist in describing significant attributes of the CBRN human response models. "Tool and Application" questions do not deal directly with the models themselves, but address oft-raised concerns of users regarding the applications that implement the model.

This report provides the results of the IDA study to identify the points of consensus and divergence; these are discussed in more detail in Chapter IV. The results of this study are intended for use by the sponsors as guidance in the development of new CBRN human response model attributes and requirements and/or the revision of existing ones.

A number of appendices provide additional information. Appendix A contains a list of the US and NATO survey questions that were used in this study. Upon completion of the majority of interviews, IDA held a consensus generation conference, on 4-5 December 2006, titled "Defining the Attributes of a CBRN Human Response Model: Consensus Development Conference." The study sponsors as well as relevant stakeholders, including all interviewees, were invited to view the preliminary results of the study and contribute further input, as necessary, to build consensus points. Appendix B contains the conference proceedings from that meeting; the final conference report, including presentations, attendees, and reference handouts, is published as a separate document. Appendix C contains the official notes, as taken by IDA and verified by the interviewees, for each US interview. Appendix D contains the NATO responses to the model attribute surveys. Appendix E contains an analysis of the interview responses. Appendix F contains the acronyms used in this study, and Appendix G lists the references.

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II. DEFINITION AND DESCRIPTION OF HUMAN RESPONSE MODELS AND THEIR ATTRIBUTES

For our purposes, the human response model, also known as a "casualty estimation model," is used to estimate the status of personnel over time and characterize the effects (i.e. the severity of signs or symptoms of the illness or injury, capability to perform certain tasks, etc.) resulting following personnel exposure to some event involving CBRN agents (or influenza). These models are used to translate the estimates of exposure to an insult, injury, or agent into the resulting effect of the insult, injury, or agent on humans. Models currently in use vary in scope and complexity. Most are based on a calculation of probable response given level of exposure and, where relevant, duration of exposure. Some human response models extend their scope to consider the time of illness or injury onset, the nature and severity of signs and symptoms, and the time to death or recovery.

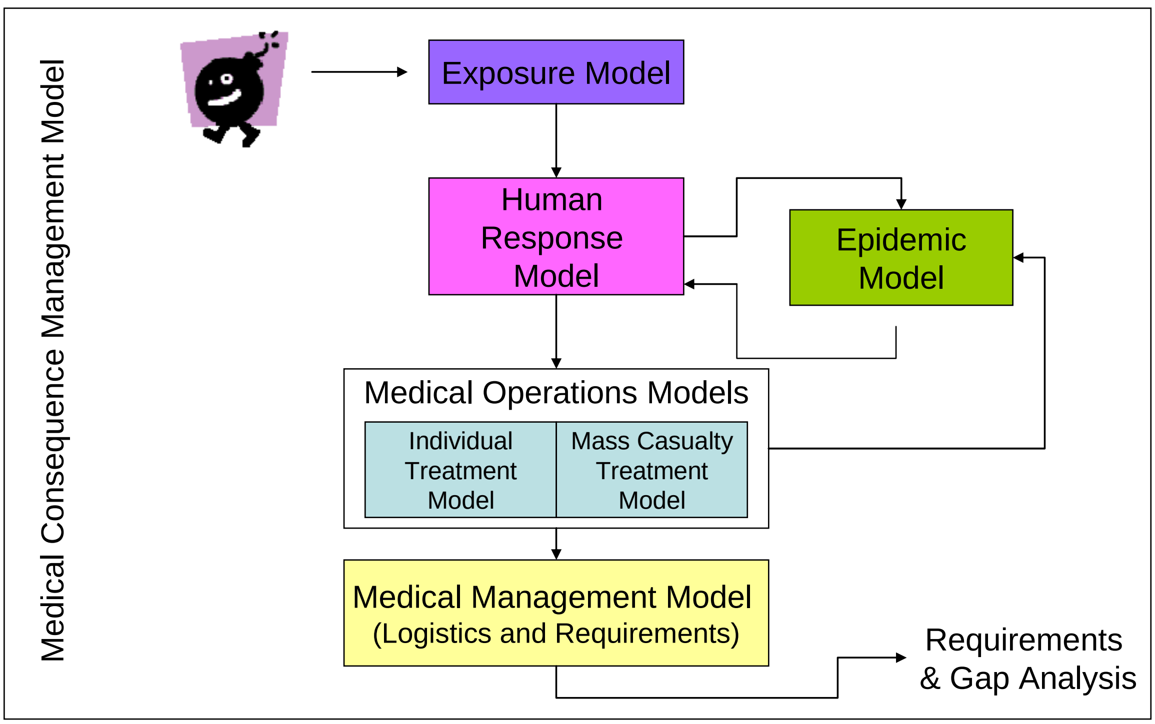

Figure II-1. Human Response Models in the CBRN Casualty Estimation Process

As shown in Figure II-1, human response models are typically just one part of a suite of models used to estimate casualties resulting from CBRN attacks. The other models in the suite provide estimates of how an agent or insult is propagated to individuals or populations, how

physical protection mitigates exposures, how detection can trigger physical or medical protection, and what the eventual "quantified" dose to the individual might be. Together, these models might consider the alteration of human response due to the use of medical countermeasures, such as vaccination or antibiotic prophylaxis; the spread of disease from the release of an agent that is human-to-human contagious; or the medical management requirements for the casualties from CBRN exposure.

These suites of models and, in particular, human response models are used throughout the military and civilian planning communities, as well as those communities responsible for preparing to respond to CBRN attacks. The models inform the estimates made by planners, policy makers, and responders regarding the number of people who may become ill or die. Further, they may also estimate when people will develop symptoms, what those symptoms might be, and how severe those symptoms could become.

The estimates from a human response model (either in conjunction with or independent of other models) are used to develop operational, logistical, and medical response plans. Human response model estimates may influence active and passive defense policies as well as those for consequence management. They may also influence research, development, testing and evaluation programs, as well as training and education curricula.

A. TYPES OF HUMAN RESPONSE MODELS

There are several human response models in use today, including log-probit models, toxic load models, performance-based models, and experience-based estimates and rules of thumb.

A **Log-probit model**, also referred to as simply as the "probit model," assumes that the probability of exposed individuals exhibiting a specified physiological response (for example, death or some incapacitating condition) can be described by a lognormal distribution. In other words, it assumes that the exposure, as represented on a logarithmic scale, that produces an effect (i.e. miosis, severe illness, death) in some percentage of the population can be modeled using a normal distribution. The log-probit model may be associated with some time; for example a Lethal Dose ($LD_{50/30}$) value would indicate the dose at which it would be expected that 50% of the exposed population would die within 30 days. Unless such a time association is included, the log-probit model typically does not provide any information regarding injury or illness onset, duration, or course. The log-probit model is generally accepted and commonly used as an approach for estimating the human response resulting in some fraction of the population due to dose.

Like log-probit models, **toxic load (or protracted exposure) models** estimate the probability of, or fraction of an exposed population expected to manifest, a given response exposed to a given dose, without any additional information about duration or course of illness or injury. Unlike the basic log-probit model, however, toxic load models account for variations of human response in individuals as a function of the duration of exposure to a specific agent or insult. “Toxic load” refers specifically to the varying human response as a function of prolonged exposure to chemical agents; the more general “protracted exposure” refers to the modeling of varying human response as a function of any CBRN dose administered over a prolonged period of time. More simply, toxic load or protracted exposure models allow for the determination of an instantaneous dose that would produce a human response equivalent to the effects produced following a prolonged exposure with time for some biological and physiological repair and removal to occur. Generally, reducing the dose rate (by prolonging the duration over which the dose is received) decreases the toxicity or infectivity of a CBRN agent or insult through mitigation by physiological repair and removal processes.

Performance-based models approximate the dose-based human response over time as a function of performance changes. Performance-based models currently in use in the United States are broadly based upon the Intermediate Dose Program (IDP) methodology developed for the Defense Nuclear Agency (DNA) in the 1980s. The IDP methodology was designed to describe the degradation of operational performance (as described by increased time to perform specific tasks) suffered by military units and personnel over time, following attacks with CBRN weapons. The methodology relies upon three fundamental assumptions: 1) the reduced capability of an individual to perform a military task can be correlated with the severity of symptoms such as nausea or headache; 2) this degredation in performance capability is the same for the same symptom severity regardless of the cause of the symptoms; and 3) the timing and severity of symptoms resulting from exposure to CBRN agents and insults can be described as a function of that exposure.

Rules of thumb and experience-based estimates or factors are also used to estimate human response and the numbers of injured, ill, or dead following a CBRN event. While not uncommon, these methods often rely on personal experience and judgment to estimate some approximation of an acceptable answer and may not be well documented or reported.

Additionally, some models incorporate statistical distributions of time to onset, time course of illness or injury, and/or time to death or recovery to describe the response of a population to CBRN attacks. These models are often used to assess the consequences of

biological agent attacks or outbreaks of infectious diseases that could have significant effects on military operations.

The fundamental assumption of most human response models is that there is a limited set of information that is known to the model user. The model estimates the variation of the human response as a function of that knowledge, and the human response estimate describes that variation as a function of the severity of the human response and, depending on the model employed, the time over which it occurs.

B. WHY A COORDINATED HUMAN RESPONSE MODEL?

Although casualty estimation tools have existed for several decades, organizations and agencies with responsibilities for CBRN response have determined in recent years that some of the existing tools (and the component human response models) are difficult to apply to specific questions or provide confusing, inadequate, or conflicting answers. The sponsors of this study, as well as several of the organization interviewed, expressed the opinion that the development and use of a suite of coordinated human response models would facilitate the execution of CBRN responsibilities across the military and at all levels of government.

Additionally, the scope of CBRN response has expanded beyond traditional battlefield threats to include new threats, such as toxic industrial chemicals, radiation dispersal devices, and pandemic influenza; new missions, such as installation security, and new requirements, such as consideration of civilian populations and higher or changing standards of medical care. Consequently, and in response to increased concerns regarding CBRN threats, scientific research and modeling of CBRN threats has also increased. Development of a coordinated human response model may potentially include the new estimation models being developed as a function of ongoing research, the expanding CBRN scope, and the update of existing human response models through the incorporation of new findings.

III. STUDY METHODOLOGY

To gather information regarding users' and potential users' desired CBRN human response model attributes, the study team used survey questions and collected responses through both interviews and written response. Although participation was requested from a number of military and civilian organizations and NATO nations identified by the study team, respondents typically self-selected and volunteered to help facilitate interview sessions or provide responses via email.

Most responses were collected through individual or group interviews conducted between July 2006 and January 2007. Generally, a team of two persons from IDA—an interviewer and a recorder—would travel to meet with organizations of interest; meetings were conducted with individual and groups of organizations depending on location and availability. The interviewer would request a short briefing on the roles and responsibilities of the interviewees in attendance and provide a short briefing on the model attributes task and IDA's role in this task. The remainder of the interview, usually between two and four hours, would be devoted to an open discussion of each topic's questions.

A. INTERVIEWEES

IDA identified US government agencies that used CBRN human response models. These agencies included the military organizations as well as civilian organizations at the federal, state, and local levels. (The complete list of organizations interviewed can be found in Table III-1.) Not including the NATO correspondence, these interviews involved more than 160 personnel. Seventy-four separate US organizations were included—represented by at least one but possibly multiple participants from each organization—conversations were held in groups; unfortunately, this sometimes resulted in difficulties capturing each independent organization's views. For the purposes of this analysis, therefore, responses from 32 site visits/organization discussions are included. This report offers organizational viewpoints expressed by participants at interview sites without attributing the comments to specific organizations. (US individual site interview results are included in Appendix C).

In addition, while more than 30 countries were contacted through the CBRNMedWG, only 5 provided written responses to the questions posed to them: Canada, Germany, Great Britain, the Netherlands, and the United States. An additional interview was conducted with

members of NATO Allied Command Transformation in Norfolk, Virginia. (NATO responses are included in Appendix D).

Table III-1. Participant Organizations

Military Operational	Military Support	Civilian
Air Force Medical Operations Agency (Science & Technology)	Air Force Institute for Operational Health	Boston Emergency Medical Services
Air Force Surgeon General	Air Force Research Lab	Boston Public Health Commission
Air National Guard Readiness Center	Applied Research Associates	CDC:
Army Office of the Surgeon General	Armed Forces Radiobiology Research Institute	Coordinating Center for Infectious Diseases/National Center for Infectious Diseases
Bureau of Naval Medicine	Army Medical Center & School	Coordinating Office for Terrorism Preparedness and Emergency Response
Commander, US Second Fleet	Armed Services Blood Program	Coordinating Office of Global Health
Commander, US Pacific Fleet	Center for AMEDD Strategic Studies	Denver Environmental Health
Jo int Task Force – Civil Support	Defense Threat Reduction Agency	Denver Fire Department
Marine Forces Command	Edgewood Chemical Biological Center	Denver Office of Emergency Management
Navy Environmental and Preventive Medicine Unit--5	Joint Requirements Office	Denver Police Department
Navy Expeditionary Combat Command	Uniformed Services University of the Health Sciences	Department of Transportation
Naval Health Research	US Air Force School of Aerospace Medicine	Federal Aviation Administration
Navy Medical Center San Diego	US Army Center for Health Promotion and Preventive Medicine	Federal Emergency Management Agency
Naval Special Warfare	US Army Medical Research Institute of Chemical Defense	LA City Emergency Preparedeness
Northern American Aerospace Defense Command	US Army Medical Research Institute for Infectious Disease	LA County Department of Mental Health
Regional Supply Office Norfolk	US Army Nuclear and Chemical Agency	LA County Public Health
Riverine Group One		LA World Airports
Special Operations Command Pacific		Los Alamos National Lab
Surface Warfare Medicine Institute		National Highway Transportation Safety Administration
Third Army / US Army Central		NYC Department of Public Health
3rd Fleet		NYC Department of Transportation
13 Air Force		NYC Office of Emergency Management
US Army Pacific		NYC Police Department
US Central Command		NY/NJ Intelligence Agency
US Fleet Forces Command		Pipeline and Hazardous Mat'l Safety Administration
US Forces Command		Sandia National Lab
US Joint Forces Command		San Diego Emergency Preparedness
US Northern Command		
US Pacific Command		

B. INTERVIEW PROCESS

This study used interviews of multiple agencies across the current and potential user community to define the desired CBRN human response model attributes. The questions were posed by electronic and written correspondence to the NATO nations and Partnership for Peace allies through the NATO CBRNMedWG. Other interviews were conducted by IDA personnel; the interviews combined briefings of the project purpose with a standardized, survey-driven open-ended interview of participants. Both the NATO and other survey questions are included in Appendix A. The interviewees included more than 160 personnel from more than sixty military and civilian organizations, including the Joint Staff and Service and Combatant Commanders' staffs, research and training institutes, as well as federal, state, and local agencies. The questions were divided into six broad topics (see Appendix A for the complete list of questions):

- Users and uses
- Inputs known to the users
- Output desired by the users
- Time dimensions appropriate to the task
- Model methodologies to be considered
- Tool and application properties desired by the user.

The questions were selected to address several points of interest to the sponsors of this study. The first set of questions, "Users and Uses," defines the scope of applications that CBRN human response models are expected to cover. "Inputs" helps to prescribe what information should be used as model inputs. "Output," "Time," and "Methodologies" each assist in describing significant attributes of the CBRN Human Response models. "Tool and Application" questions do not deal directly with the models themselves but rather address oft-raised concerns that the model users have regarding the applications that implement the model.

IDA analyzed the interview responses to identify the points of consensus and divergence. The results of this analysis were intended for use by the sponsors of this task as guidance for the development of new and/or the revision of existing CBRN human response models.

C. INTERVIEW LIMITATIONS

There are several potential limitations to the interview process employed throughout the course of this study, including lack of participant responses to some questions and participant bias. As much as possible, these were minimized throughout the interview process through the

use of a standardized question set and formatted boards on which answers were recorded, however, it is important to note that these limitations may exist.

There are several possible reasons for a lack of response to a question, including: 1) the participant organization did not have input; 2) the question was not asked at the particular interview site; or 3) the response to the question led to discussion more applicable to, and included in, an alternate question. Additionally, for questions that invoked discussion among interview participants, there is a limited possibility that some responses were inadvertently omitted from the record. To avoid this, answers were reviewed with participants during the session, and participants were given the opportunity to review and comment on session notes following the interview. Nevertheless, the lack of an answer by a particular interview site may not indicate that the question or response was unimportant to the interviewees, but rather that the response may not have surfaced or been captured during the interview process. Numbers on how many participants answered each question are included in Appendix E.

In addition, personal biases of the interview participants may have affected the responses. A few users noted that their organization either does not currently use models or uses model results produced by a single member of the organization or an external organization. Others did not recognize the tools they used as human response models. For those interviewees who did use models, the current users included surgeons, medical personnel, and public health officials; planners; and operations, incident analysis, and emergency managers. Other model users included first responder organizations, personnel managers, and research and general modelers. Interviewees identified additional user groups that might also find utility in human response models. So while the interviewees, types of users, and organizations varied widely across current and potential users at all levels of the military and government, these responses represent only a sampling of the possible users and responses.

IV. INTERVIEW FINDINGS

As previously noted, the interviews focused on several topic areas, including users and uses; model inputs; model outputs; time; methodologies; and tools and applications. This section briefly discusses the responses and includes the percentage of the user communities expressing agreement for convergent responses (i.e. where the interviewees generally agreed on an area of discussion). The responses, including the statistics regarding number of participating respondents and consensus and divergent responses, are discussed in more detail in Appendix E. [5]

A. USERS AND USES

Most of the organizations interviewed currently use models. At these organizations, current modelers include operations and emergency managers; logistics, operations, personnel, and medical planners; surgeons, medical personnel, and public health; laboratories and research centers, and first responder organizations, including Weapons of Mass Destruction Civil Support Teams. Several interviewees suggested that additional groups within their organizations might benefit from the use of models as well. Beyond the current user groups already identified, interviewees suggested that public affairs, mortuary affairs, intelligence organizations, doctrine developers, security organizations, and others might also benefit from the use of human response and other models.

The models that were listed by the interviewees as being "in-use" include casualty estimation tools associated with plume models; probit models; pandemic and epidemic models; epidemiological models; resource tracking and logistics models; and rules-of-thumb. Additionally, multiple organizations indicated that they rely on external organizations – DTRA, National Laboratories, federally funded research and development centers, or the Federal Radiological Monitoring and Assessment Center – to provide their modeling capabilities.

Participants classified model functions on the basis of the times they are used in relation to the time of the event: models may be used before an event to help prepare for it, or they may

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[5] Because response percentages are calculated versus the total number of interview sites, some values may appear lower than anticipated. As discussed previously, this may be the result of a number of reasons, including but not limited to limited discussion on a topic at a particular site or a question not having been asked at a particular site. It is important to note that low percentages may not indicate a lack of response importance, but rather that the response did not come out specifically in the discussions conducted.

be used either during the course of an event or following the event to assist the response or to aid the event analysis. Interviewees anticipated using the models to help answer various questions, including those pertaining to planning, training and exercises, resource estimation, event/outcome prediction, policy or concept of operations support, retrospective analysis and analysis of alternatives, and epidemiological or reverse tracking.

Interviewees also suggested several ways that existing models could be improved. Users suggested that models should be:

- compatible with existing models and platforms;
- credible, transparent, documented, and incorporating a method for assessing the results;
- designed to address the users' questions;
- publicly available (at least to users) with standardized training;
- based on the best available data; and
- based on a common terminology with accepted definitions.

Additionally, although raised by multiple organizations, civilian sites specifically raised the necessity of accounting for population variance as a function of time and event (i.e. some cities' populations are significantly larger during working hours than on evenings or weekends).

B. INPUTS

Interviewees generally agreed that model inputs should include biological, chemical—warfare agents and toxic industrial chemicals, nuclear, radiological, and explosive hazards. Some divergence was noted here; some participants did not agree that one or more of the above agents needed to be included in human response models. Most interviewees agreed, however, that, while they might not elect to model a particular hazard, inclusion of the hazard in a suite of models or tool would not preclude their overall use of the tool.

Participants agreed that all applicable exposure routes—inhalation, ingestion, dermal or cutaneous, and others—should be included. While ocular exposure, secondary infection, and human and animal vectors were less frequently mentioned, when asked specifically about these methods of transmission, respondents agreed that they should also be included where applicable. Additionally, both military communities expressed interest in the inclusion of combined routes of exposure and multiple, simultaneous, or near-simultaneous insults (e.g. radiological and biological insults).

"Population at risk" was defined two specific ways in conversation: 1) the size of the population to be modeled; and 2) the anticipated changes in the population size. Regarding this

parameter, respondents agreed that military and civilian populations should be differentiable or that other filters (e.g. first responders, first receivers, indigenous populations, etc) should be available for differentiating populations. Interviewees also agreed that the population to be modeled might vary significantly in size “from five to five million.” Interviewees in the military support and civilian communities also suggested that populations within the model be variable to account for changes during day as opposed to night and special events. Most participants also agreed that population demographics should be considered, but there was limited-to-no consensus as to which demographics should be included in future models due to the various roles and responsibilities of the organizations represented. Among the most commonly suggested parameters were age, health status, and gender. Additional recommended demographics included language and other conformance factors—demographics that might preclude a population’s willingness or ability to conform to stated requirements or protective actions. It should be noted that while many requested population demographics, most also noted that information pertinent to human response as a function of the requested population demographics might not be available.

Most interviewees also agreed that medical protection, which for the purposes of this question included both medical prophylaxes and personal protective equipment, should be considered in the models. The civilian community, in particular, expressed the desire to be able to model both with and without medical protection: “We want to model what we actually have, not plan on doing what-if scenarios.” Conversely, interviewees varied in their desire for inclusion and representation of treatment: e.g., types of treatment; levels of treatment; existence of efficacy data; and clinical outcomes.

A significant number of interviewee organizations favored modeling technical detection (i.e. agent or radiological detectors providing an indication of hazard presence), syndromic surveillance (i.e. illness or injury outbreak identification system based on prevalence of symptoms in a population), or a combination of both. Participants requested these be included even though some users considered these attributes extraneous to a human response model.

Additionally, participants generally agreed that some model input information they might have readily available—for example, a city might know its local population distribution during the day and at night or a military modeler might have intelligence regarding likely attack locations and agents—and other information they would not. Therefore, the models should have some way for users to provide data of their own, import data from available sources (i.e. population data from national databases), and change or use default values already established within the models.

C. OUTPUTS

Participants agreed that the basic human response model outputs should include the numbers of casualties (defined for the purposes of these conversations as ill, injured, and/or dead). Additionally, the participants widely agreed that the models should provide changes in numbers of casualties and casualty status over time.

Interviewees mostly agreed that the casualty outputs should be able to be binned, categorized, and filtered; there appeared to be consensus that because different users would need different information, the more ways that outputs could be represented the better. Binning casualties referred to separately estimating and differentiating numbers of dead versus ill and/or injured. According to participants, categorizations could include, but are not limited to, type of injury or illness, severity of illness, symptoms or systemic effects, and performance level. Additionally, interviewees wanted the ability to filter outputs according to population type (i.e. civilian, military, medical staff, first responders, etc.)

When asked specifically, more than half of the interviewees recommended that the threshold or criteria by which a casualty is defined (i.e. doctrinal definition, specific symptom onset, illness severity level, capability decrement, etc.) should be user-selectable; preset default values should also be included according to participants. The desired outputs along with the percentage of respondents desiring the information is summarized in Table IV-1.

Table IV-1. Desired Outputs

What information should the models output?	
Numbers and Time phase of:	
- Persons who did not exhibit symptoms	16%
- Casualties (ill or injured)	94%
- Fatalities	31%
- “Worried Well”	25%
- Psychological casualties	25%
Status of Casualties over time, grouped by categories:	66%
- Type of injury or illness	40%
- Severity of injury or illness	16%
- Symptoms/systemic effects	34%
- Clinical outcome (without treatment)	16%

While interviewees agreed on the importance of knowing the numbers of casualties who present to the medical system, interviewees did not necessarily agree that medical treatment and its impact on casualties should be modeled. Those who favored modeling treatment requested even more information from the human response model; they desired the number of persons

requiring treatment and how the number varies over time; the number of people requiring treatment grouped by patient condition code (for military use) or triage levels (for civilian use), allowing estimation of the types of treatment required; the post-treatment clinical outcome or fate of patients; and resources required for treatment.

Additionally, beyond the actual outputs the human response should provide, the interviewees generally concurred that having confidence in the models and seeing that confidence expressed in quantitative and/or qualitative methods was important. Interviewees agreed that outputs should convey a level of fidelity appropriate to the availability and accuracy of underlying data. They also wanted the models to report the significant factors contributing to the confidence assessment, such as confidence in the underlying data, confidence in its applicability to the scenario, confidence in inputs, etc. Interviewees disagreed, however, on how confidence should be expressed. Most interviewees suggested using a quantitative expression of confidence with traditional confidence intervals (levels) and their upper and lower boundaries (limits), while others contended that a qualitative expression of confidence—e.g., color-coding; high, medium, and low bins; subject matter expert confidence—would be sufficient.

Participants, however, were not always specific or in agreement in regards to the attributes and/or output values for which confidence should be expressed. Overall model confidence would be a function of, at least, the data used to estimate the exposure environment, the population at risk, and the human response to CBRN agents and insults. Confidence in each of these estimates, as well as the underlying parameters on which the estimates are based—agent (or insult) characteristics; population distribution, physiologies, demographics, and other factors; routes of exposure; dose-response relationships; and impacts of medical countermeasures on human response among others—would each be necessary to estimate confidence in each model or in the output values calculated by the entire suite of models.

D. TIME

The interviewees were unanimous that time was an important parameter for human response models. As an input parameter, users wanted to include various time-based inputs: time of exposure, time of providing medical interventions, time of patient presentation to the medical system, and time of casualty and/or symptom onset. Many interviewees felt that the granularity of input times (minutes, hours, days, etc.) should be appropriate to the agent.

The interviewees were also unanimous that time should be considered as a model output parameter. Regarding the time intervals or granularity that should be reported, answers ranged from minutes to hours to days. While interviewees did not agree on the smallest time unit for reporting, they generally agreed that outputs should be reported over increasing time intervals.

Many interviewees suggested reporting minutes or hours initially, then days, then weeks or months. There was also consensus on the agent-dependent nature of time intervals. Regarding the maximum length of time desired for reporting outputs, answers also varied among interviewees. Suggestions for this attribute depended on the responsibilities or missions of highest concern. Most interviewees expressed the desire to consider one or more effects periods for observing casualties. Of those who provided an answer, almost all agreed that acute effects should be considered and reported in the models. Most interviewees were also interested in delayed or latent effects and chronic or long-term effects.

E. METHODOLOGIES

Many interviewees felt that users often do not know enough about the methodologies for calculating CBRN human response to express a preference. As a result, interviewees made the general recommendation that the methodology most appropriate to the agent, population, response, and level of detail required for modeling is the one which should be used. Additionally, interviewees indicated that multiple methodologies may be required to model all of the agents in consideration.

Several did not specify a particular methodology, but rather expressed characteristics of the methodology that they would like to see included. Regardless of the methodologies to be used, many interviewees desired complete transparency of the models, but many noted that transparency might be achieved through documentation. Slightly less than half of the interviewed organizations (including some of those who expressed a desire for complete transparency) requested a black box model for at least some, if not all, of the users. Responses between these two included requests for detailed documentation of the assumptions and variables, incorporation of references, and insight into methodology and data sources. Interviewees also stressed that efforts to make models transparent should not complicate the model. Furthermore, interviewees stressed that models should be accepted by an authoritative organization and “scientifically defensible, valid, and reliable.”

F. TOOLS AND APPLICATIONS

In addition to topics specifically related to the attributes of a human response model, questions were asked regarding which platforms, programs, formats, and support the user community felt were necessary in order for the CBRN human response models to effectively answer user questions and meet user needs. Interviewees agreed that the choice of platform matters, with different platforms necessary to meet the needs of different users: in general, program and platform must meet established organizational and computer compatibility requirements.

The consensus among interviewees was that a graphical user interface (GUI) was desirable. The GUI should be as simple as possible, while maintaining functionality: interviewees agreed that a user-friendly tool was required. Additionally, the GUI would ideally incorporate default and recommended settings, provide ability to select alternative inputs (options) and to input local information and data and change inputs, and include guidance for and ability to input specific information. Participants recommended that links providing information regarding data sources, references, user-support (or "help") and other requested supporting details be included.

Interviewees also agreed that the tool should have the capability to import and export inputs and export outputs to other systems for graphing, presentation, or documentation purposes. In the special case of current event response, the model should take real-time data inputs and update continuously. Moreover, the tool should be compatible with a number of common programs.

Additionally, interviewees clearly recognized that training and support are required and should be ongoing. Furthermore, there was broad consensus that model usage is understood to be an expendable skill, so refresher training must be available. It was widely agreed, moreover, that training should vary by user-level. Finally, all respondents expected some support in using the models. Support would ideally include around-the-clock reach-back capability that would assist both running the model and assessing results.

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V. ANALYSES OF DESIRED ATTRIBUTES

Having assembled, reviewed, and compared the set of attributes of a human response model desired by the participant collection of civilian and military organizations, the next step was to determine which attributes a model (or models) would need to perform the variety of desired functions. For example, which attributes and associated information would a model need to have for it to represent the human response to the effects of a VX attack in the manner and detail required by the user community? To begin this task, the study team, in conjunction with local subject matter experts (SMEs), organized the consolidated interview responses into one or more of seven broad categories:

1) Attributes that would apply independent of the type of agent involved (described as “overarching” attributes);
2) Attributes impacting but not directly pertinent to a human response model;
3) Attributes that pertain specifically estimation of human response;
4) Attributes specific to chemical agents;
5) Attributes specific to biological agents;
6) Attributes specific to radiation exposures;
7) Attributes specific to nuclear fission/fusion explosions.

The attributes templates are intended to identify the information that would be necessary to model human response. For the most part, these attributes were identified by the interview participants; however, where necessary, the study team added attributes deemed influential for the required calculations. The first template—overarching attributes—outlines information that the model would need to have, but that is external to the actual human response and casualty estimation processes. The second template identifies attributes which might impact human response and casualty estimation, but which might be external to the model as well. The next set of attributes pertain to estimation of human response for CBRN events. The aim of this attribute set is to identify the full range of data that might be necessary to model each specific agent or insult; only the applicable categories and subcategories should be used for each agent (i.e. a user might opt to neglect dermal effects following sarin exposure due to the agent’s volatility). The final set of templates list agents, insults and events, as identified by the interviewees, that might be considered for incorporation in the human response models.

A. OVERARCHING AND EXTERNAL ATTRIBUTES TEMPLATES

Overarching attributes included such factors as population (e.g. daytime vs. nighttime populations) and demographic factors, the employment of confidence intervals in both model input and output, and the use of time as both an input to and an output from the model (see Table V-1). Among the attributes identified by users as external to, but still impacting the results of the human response model, were physical protection (both personal and collective), detection, and surveillance (see Table V-2). The “tool” attributes included such items as the types of platforms and operating systems the model should run on, the types of file formats or software from which it could receive input, and in what types of formats or to what types of analysis/database software the model should output results. Attributes in these first three categories were identified but, aside from some general SME comments, no further action has been taken on these attributes (see Appendix E). For the attributes in each of the agent classes (categories four through seven), a template of functions and sub-functions required to meet the respondents’ set of desired attributes was developed. Developing each template followed a multi-step process: 1) the development of functional templates for chemical and biological agents, radiation events, and nuclear explosions; 2) the identification of agents of interest in each agent class; and 3) the crosswalk of agents and relevant functions.

Table V-1. Overarching Attributes

Population-Demographic Factors	**Time**	**Output**
Age	Inputs	Casualties
Elderly	Time of Exposure	Signs/Symptoms
Children	Duration of Exposure	Fatalities
Health Status	Time of Medical Protection	Capable
Normal	Duration of Med. Protection	RTD vs. Convalescent
Immune Compromised	Time of Treatment	“Worried Well”
Comorbidities	Duration of Treatment	Psychosomatic
Pregnancy	Time of Symptom Onset	Unrelated/Associated Symptoms
Conformance	Outputs	
Physical Special Needs	Time to Recovery/Time to Death	
Language	Casualty Status	
General Population	Exposure Status	
Other Potentially Non-conforming Populations	“Capable Status”	
Population Type	Mortality Status	**Confidence Intervals**
Civilian		Input
Military		Qualitative
First-Responders		Quantitative
Gender		Output
Male		Qualitative
Female		Quantitative

Table V-2. Attributes Outside a Human Effects Model

Physical Protection	**Technical Detection (Triggering Function)**	**Syndromic Surveillance (Triggering Function)**
Personal Protective Equip.	Type of Detector	Type of Surveillance
Industrial/Surgical Masks	Time to Detect	Time to Detect
Filtered Masks	Time to ID	Time to Diagnose
Self-Contained Breathing Apparatus	False Positive Rates	Patient Reporting Rate
“MOPP” Gear	Time to Act	Time to Act
Regular Clothing	Type of Treatment	
Structural	Time of Treatment Administration	
Vehicular	Post-Treatment Modified	
Building	Response Function	
Collective Protection		

B. CHEMICAL, BIOLOGICAL, AND RADIATION EVENTS TEMPLATES

For chemical and biological agents and radiation events (see Tables V-3 through V-5), four broad categories of functions were used: route of exposure, medical protection, medical treatment, and time. Each of these categories was subsequently broken down into more detailed

subcategories (where relevant) and then specific functions or variables were listed for all categories or subcategories.

1. Routes of Exposure

Four routes of exposure for chemical agents were considered: inhalation, dermal, ingestion, and ocular. For each of these routes, three methodology functions were suggested: human response effects, time to effects onset, and course and durations of illness. In all but the ocular case, a fourth functional option titled "toxic load" was also included. Methodology functions are the methods by which the human response is quantitatively described.

Four routes of exposure were also considered for biological agents: inhalation, dermal, ingestion, and human vector or secondary infection. For the first three of these exposure routes, the same three methodology functions as suggested for chemical agents were identified: human response effects, time to effects onset, and course and durations of illness. The human vector/secondary infection category may require different functions/variables, for example secondary infectivity or infection transmissivity.

Similarly, four routes of exposure were considered for radiation events: inhalation, dermal, ingestion, and external radiation exposure. For all four routes, four methodology functions were identified: human response effects, time to effects onset, course and time of illness, and calculations related to toxic load (or protracted dose).

2. Medical Protection

"Medical protection" is defined as any medical countermeasure administered before the onset of symptoms to provide protection against illness or death or any countermeasure that may be self-administered after the onset of symptoms without consulting a medical professional. For chemical agents, medical protection was disaggregated into three subcategories: pharmaceutical protection that would be administered prior to exposure (pre-exposure pharma), pharmaceutical protection that would be administered after exposure (post-exposure pharma), and pharmaceutical protection that would be administered both before and after exposure (pre- & post-exposure pharma). Examples of such protection include topical agents (pre-exposure pharma) and atropine (post-exposure pharma). Within each of these subcategories, the following factors were identified: time of protection administration, modified response factors, efficacy of protection, and modified signs and symptoms.

Similarly for biological agents, medical protection was divided into two subcategories: the use of chemical agents to prevent the development of a disease (chemoprophylaxis) and the enhancement of active or passive immunity to prevent the development of a disease

(immunoprophylaxis). Within both of these subcategories the following functions/variables were identified: time of protection administration, modified response factors, and efficacy of protection.

For radiation events, only pharmaceutical medical protection was specified, along with the following four factors: time of protection administration, modified response factors, efficacy of protection, and modified signs and symptoms.

3. Medical Treatment

"Medical treatment" is defined as the care provided in a medical facility by medical professionals following the onset of symptoms. Four potential factors were associated with treatment for chemical, biological, or radiation events: type of treatment, time of treatment administration, post-treatment modified response factors, and efficacy of treatment.

4. Time

For all three agent/event classes, time was divided into two variables: the total time for which the model must track the agent effects (time interval) and the smallest increments of time for which the model must track agent effects (time period). The time interval was measured by the type of effects (by time) that must be tracked, ranging from acute (the shortest) to chronic (the longest). The time period could range from seconds to minutes, hours, days, or weeks depending upon the agent, the details of the model, and the intended purpose of the model.

Table V-3. Attributes of a Human Response Model for Chemical Agents

Route of Exposure	Medical Protection	Treatment
Inhalation	Pre-Exposure Pharma	Treatment
Methodology Function	Time of Protection Administration	Type of Treatment
Time to Onset	Modified Response Factors	Time of Treatment Administration
Course and Times of Illness	Efficacy of Protection	Modified Post-Treatment Response Function
Toxic Load Calculation	Modified Signs and Symptoms	
Dermal	Post-Exposure Pharma	Efficacy of Treatment
Methodology Function	Time of Protection Administration	Modified Post-Treatment Signs and Symptoms
Time to Onset	Modified Response Factors	
Course and Times of Illness	Efficacy of Protection	
Toxic Load Calculation	Modified Signs and Symptoms	
Ingestion	Pre- & Post- Exposure Pharma	
Methodology Function	Time of Protection Administration	
Time to Onset	Modified Response Factors	
Course and Times of Illness	Efficacy of Protection	
Toxic Load Calculation	Modified Signs and Symptoms	
Ocular		
Methodology Function		
Time to Onset		**Time**
Course and Times of Illness		Reporting Time Interval
Toxic Load Calculation		Reporting Period

Table V-4. Attributes of a Human Response Model for Biological Agents

Route of Exposure	Medical Protection	Treatment
Inhalation	Chemoprophylaxis	Type of Treatment
Methodology Function	Time of Protection Administration	Time of Treatment Administration
Time to Onset	Modified Response Factors	Modified Post-Treatment Response Function
Course and Times of Illness	Efficacy of Protection	
Dermal	Immunoprophylaxis	Efficacy of Treatment
Methodology Function	Time of Protection Administration	
Time to Onset	Modified Response Factors	
Course and Times of Illness	Efficacy of Protection	
Ingestion		
Methodology Function		
Time to Onset		
Course and Times of Illness		
Human Vector/Secondary Infection		
N-value		
P-value		**Time**
Spread Factor		Reporting Time Interval
Course and Times of Illness		Reporting Period

Table V-5. Attributes of a Human Response Model for Radiological Agents

Route of Exposure	Medical Protection
Inhalation	Pharma
Methodology Function	Time of Protection Administration
Time to Onset	Modified Response Factors
Course and Times of Illness	Efficacy of Protection
Protracted Exposure & Effects	Modified Signs and Symptoms
Dermal	
Methodology Function	
Time to Onset	**Treatment**
Course and Times of Illness	Type of Treatment
Protracted Exposure & Effects	Time of Treatment Administration
Ingestion	Modified Post-Treatment Response Factors
Methodology Function	
Time to Onset	Efficacy of Treatment
Course and Times of Illness	Modified Post-Treatment Signs and Symptoms
Protracted Exposure & Effects	
External Radiation Exposure	
Methodology Function	
Time to Onset	**Time**
Course and Times of Illness	Reporting Time Interval
Protracted Exposure & Effects	Reporting Period

C. NUCLEAR FISSION/FUSION EXPLOSIONS TEMPLATE

Given the nature of its effects, the "nuclear fission/fusion explosions" agent class was categorized differently from the other three agent classes (see Table V-6). Rather than "routes of exposure," nuclear effects were divided into different types of insult: blast, thermal, prompt radiation, and combined effects. For each of these insults, two functions were identified: methodology factors and course and times of illness. A third function was added to the "combined effects" insult: specifically, a determination of how the three pure insults (blast, thermal, and prompt radiation) interacted with one another in the human body ("combinatorial factors"). Effects due to "delayed" radiation—i.e., fallout—were anticipated to be considered under the radiation events class. No medical protective measures were identified for nuclear explosions. Medical treatment was divided into three categories of injury: trauma, burn, and radiation. For each of these injuries, three functions/variables were identified: type of treatment, time of treatment administration, and post-treatment modified response factors. Finally, time was categorized in the same fashion as the other three agent classes (i.e., by time interval and time period).

Table V-6. Attributes of a Human Response Model for Nuclear Explosions

Insult	Treatment
Blast	Trauma
Methodology Function	Type of Treatment
Course and Times of Illness	Time of Treatment Administration
Thermal	Modified Post-Treatment Response Function
Methodology Function	
Course and Times of Illness	Burn
Prompt Radiation	Type of Treatment
Methodology Function	Time of Treatment Administration
Time to onset	Modified Post-Treatment Response Factors
Course and Times of Illness	
Combined	Radiation
Methodology Function	Type of Treatment
Combinatorial Function	Time of Treatment Administration
Course and Times of Illness	Modified Post-Treatment Response Factors
	Time
	Reporting Time Interval
	Reporting Period

D. AGENTS

After developing these templates, the specific agents in each agent class that a human response model might represent were determined based on participants' input. Nine different chemical agents were identified, including weaponized agents and toxic industrial chemicals (TICs) (see Table V-7). Thirty-one specific biological agents were identified, ranging from animal diseases that might affect humans to weaponized, non-weaponized, and pandemic human-specific diseases (see Table V-8). Radiation events were divided into four categories: fallout (typically associated with nuclear explosions); radiation produced by the intentional spread of radiation contamination or Radiological Dispersal Devices (RDDs), which may include a dirty bomb, or radiation sprayer; surface contamination radiation, including that produced by fallout particles or RDDs deposited on surfaces; and any additional techniques for causing radiation exposure (Intentional Other), such as the placement of a radioactive source in a planter (see Table V-9). Nuclear fission/fusion explosions represented a single agent.

Table V-7. Chemical Agents Considered

Weaponized	Industrial
Nerve Agents	Toxic Industrial Chemicals (TICs)
G-series	Chlorine
GB	Phosgene
VX	Hydrogen Cyanide
Future Chemical Agents	Toxic Industrial Materials (TIMs)
Mustard Agent	HAZMAT
Choking	
Cyanide	

Table V-8. Biological Agents Considered

Weaponized	Non-Weaponized	Animal Diseases
Bacterial	Bacterial	FMD
Anthrax	Bordatella Pertussis	Rabies
Tularemia	Salmonella	Avian Influenza
Glanders	Viral	
Brucellosis	Pandemic Flu	
Plague	Lassa	
Q-fever	Dengue	
Typhus	West Nile	
Viral	Measles	
Smallpox	Hepatitis A	
VEE	SARS	
Ebola	Parasitic	
EEE	Cryptosporidium	
Marburg	Toxin	
Toxin	Aflatoxin	
Botulinum Toxin	Saxitoxin	
Ricin	Microcystins	
SEB		

Table V-9. Radiological Events Considered

Fallout
Radiological Dispersal Device (RDD)
Surface Contamination Radiation
"Intentional Other"
In particular a method for causing radiation (vice contamination)

The SMEs were then tasked with examining each identified agent, determining which functions/variables (in the agent's relevant agent class template) applied to that agent, and specifying any additional special considerations relevant to the modeling of that specific agent and function/variable. In the case of Sarin (GB), for example, only inhalation and dermal routes

of exposure were considered relevant, and only post-exposure medical protection would be expected to be available. Sample results for chemical and biological agents, radiation events, and nuclear explosion are shown in Tables V-10 through V-15.

Table V-10. Example of Attributes Specified for a Particular Chemical Agent (GB)

Route of Exposure
Inhalation
Methodology Function
Time to Onset: Performance-based; other methods?
Course and Times of Illness: Performance-based; other methods?
Toxic Load Calculation: Data may or may not exist
Dermal
Methodology Function
Time to Onset: Performance-based; other methods?
Course and Times of Illness: Performance-based; other methods?
Toxic Load Calculation
Medical Protection
Post-Exp Pharma
Time of Protection Administration
Modified Response Factors: Dose Dependent
Efficacy of Protection: Dose Dependent
Modified Signs/Symptoms: Varies with dose and time of administration
Treatment
Type of Treatment: Not specific
Time
Reporting Time Interval: Acute
Reporting Period: At least minutes, hours, days; possibly seconds depending on level of detail available; and possibly longer than “days” depending on user needs

Table V-11. Example of Attributes Specified for a Particular Chemical Agent (Mustard)

Route of Exposure

Inhalation

Methodology Function

Time to Onset: Performance-based; other methods?

Course and Times of Illness: Performance-based; other methods?

Toxic Load Calculation

Ocular

Methodology Function

Time to Onset: Performance-based; other methods?

Course and Times of Illness: Performance-based; other methods?

Medical Protection

Pre-Exp Pharma (Topical)

Time of Protection Administration

Modified Response Factors

Efficacy of Protection: May vary with dose, correct application and time of administration

Modified Signs/Symptoms: May vary with dose, correct application and time of administration

Treatment

Type of Treatment: Not specific

Time

Reporting Time Interval: Acute

Reporting Period: At least minutes, hours, days; possibly seconds depending on level of detail available; and possibly longer than "days" depending on user needs

Table V-12. Example of Attributes Specified for a Particular Biological Agent (Anthrax)

Route of Exposure

Inhalation

- Methodology Function
- Time to Onset: Multiple methods for estimating, including KAMI (Knowledge Acquisition Matrix Instrument)
- Course and Times of Illness

Dermal

- Methodology Function
- Time to Onset: Unknown method for estimating
- Course and Times of Illness

Ingestion

- Methodology Function
- Time to Onset: Multiple possible methods for estimating
- Course and Times of Illness

Medical Protection

Chemoprophylaxis

- Time of Protection Administration
- Modified Response Factors
- Efficacy of Protection

Immunoprophylaxis

- Time of Protection Administration
- Modified Response Factors
- Efficacy of Protection

Treatment

- Type of Treatment
- Time of Treatment Administration
- Post-Treatment Modified Response Function
- Efficacy of Treatment

Time

- Reporting Time Interval: Latent, protracted, chronic and acute
- Reporting Period: Seconds, minutes, hours, and days

Table V-13. Example of Attributes Specified for a Particular Biological Agent (Tularemia)

Route of Exposure
Inhalation
Methodology Function
Time to Onset: Multiple methods for estimating, including non-KAMI
Course and Times of Illness
Medical Protection
Chemoprophylaxis
Time of Protection Administration
Modified Response Factors
Efficacy of Protection
Immunoprophylaxis
Time of Protection Administration
Modified Response Factors
Efficacy of Protection
Treatment
Type of Treatment
Time of Treatment Administration
Post-Treatment Modified Response Function
Efficacy of Treatment
Time
Reporting Time Interval: Latent, protracted, chronic and acute
Reporting Period: Seconds, minutes, hours, and days

Table V-14. Example of Attributes Specified for a Particular Radiological Event (ie. Radiological Dispersal Device (RDD))

Route of Exposure
Inhalation (Internal Contamination)
Methodology Function (ED, LD)
Time to Onset
Course and Times of Illness
Toxic Load Calculation: Must be included
Dermal (External Contamination)
Methodology Function (ED, LD, and possibly rad-based performance calculation)
Time to Onset
Course and Times of Illness
Toxic Load Calculation: Should be included if looking at exposure over long time period
Ingestion (Internal Contamination)
Methodology Function (ED, LD, other?)
Time to Onset
Course and Times of Illness
Toxic Load Calculation: Must be included
External Radiation Exposure
Methodology Function
Time to Onset
Course and Times of Illness
Protracted Exposure & Effects
Medical Protection (specific to isotope)
Time of Protection Administration
Modified Response Factors
Efficacy of Protection
Treatment
Type of treatment varies significantly depending on radioactive source, level of contamination, etc.
Time
Reporting Time Interval: At least acute, latent and protracted; possibly chronic
Reporting Period: Minutes, hours, days and possibly longer

Table V-15. Attributes Specified for a Nuclear Detonation

Insult
Blast
Methodology Function
Course and Times of Illness: Signs/symptoms; other methods?
Thermal
Methodology Function
Course and Times of Illness: Signs/symptoms; other methods?
Radiation
Methodology Function
Course and Times of Illness: Signs/symptoms; other methods?
Combined
Methodology Function
Combinatorial Function: Performance curves based on SME input; other methods?
Course and Times of Illness: Each sign/symptom for RBT insults represented separately
Treatment
Trauma
Type of Treatment: Individual basis
Burn
Type of Treatment: Individual basis
Radiation
Type of Treatment: Individual basis
Time
Reporting Time Interval: At least acute, latent and protracted; possibly chronic as well
Reporting Period: Minutes, hours, days and possibly longer

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VI. CONCLUSIONS AND NEXT STEPS

A number of organizations across all levels of the military operational, military support, and civilian communities were interviewed as part of this study, yet they represent only a small segment of the overall existing and potential user communities. Still, among these users and potential users, some important points of consensus were reached. Interviewees generally agreed that models could serve multiple functions, including planning, training, response, and resource estimation. They agreed that the full spectrum of CBRN agents should be included in the human response models, even if not all the interviewees agree that the agents were applicable within their own perceived threat spectrum. They agreed that the applicable routes of exposure (including but not limited to inhalation, ingestion, and contact) should be included, as well as both medical and personal protections that might preclude or limit such exposure.

With regard to modeling populations, the interviewees agreed that a wide variety of population sizes, types, and variance might need to be measured. They also agreed that certain demographics should be included—for example, age, health status, and gender—to the extent that data existed pertaining to the human response model.

Further, although users did not always agree how they would use the outputs, interviewees did agree that models should output the estimated number of casualties and fatalities over time. Users agreed that casualties should be further differentiated by type, severity, signs and symptoms, or systemic effects—although not all users agree on the appropriate differentiation—and that there should be some method for generating user-defined casualty levels. Interviewees also agreed that both inputs and outputs must be expressed in terms of time and that time intervals should be selected as applicable to the agent or event being modeled.

Although interviewees were not always familiar with the methodologies being employed, they did agree that methodologies should be selected for each agent or insult that would be applicable, credible, scientifically defensible, and thoroughly documented.

Utilizing these areas of consensus, initial templates describing the attributes necessary to conduct human effects modeling functions were developed. These modeling functions include the attributes described by the user communities, as well as the additional necessary variables, factors, and functions that may be necessary to implement the desired estimation process in a suite of human response models. These lists may be described as overarching data required to

implement a human response model; attributes external to, but impacting, the human response model; attributes specific to the capabilities of a tool or application of the model; and attributes specific to chemical agents, biological agents, radiological exposures, and nuclear fission/fusion explosions.

The resulting templates of human effects modeling functions, while of interest, represent only an intermediate step in the overall process. The next step would be to have SMEs from both the military and civilian threat evaluation communities identify applicable threat agents and assign rankings or priorities to the identified agents. The rankings would need to combine an assessment of the likelihood of the use or availability of these agents with the consequences of their use. Following agent and insult ranking, modeling attributes could be compared and prioritized as applicable to, at least, the top tier of agents (e.g., top 10 agents, top 50 agents, etc.) as determined in the previous step. This step would be performed by a set of SMEs chosen to represent the needs of both the military and civilian health communities.[6] Several threat agent lists and rankings already exist and while they share many agents, they do not all agree on which agents should always be considered or in which priority. Provided consensus could be achieved across the interested communities, one of the existing lists could be used to establish the agent and insult rankings for consideration in the model.

The resulting agent-specific functional priorities can be used to develop a set of tasks, requirements, and model capabilities for the modeler or the modeling community in consultation with the model sponsors. The results of this analysis are intended to be used by the sponsors of this task (OTSG, DTRA, HHS) as guidance for the development of new and existing CBRN human response models. Additionally, the analysis results may also aid in the follow-on verification, validation, and accreditation of the resulting human effects model. While it is not expected that every attribute identified in this study will be available in every tool or application that uses CBRN human response models, it may reasonably be expected that overarching attributes common to all of the interviewees should be considered for inclusion in the applications. Additionally, user-specific desires and requests may be considered for tools designed for specific uses. Additional functions, attributes, and requirements, not identified during the interviews, however, may also be necessary and may even be given higher priority in order to ensure that user needs are met with human response tools and applications.

6 For a description of such a process, see W.M. Christenson, et.al., *The Incubator Process: Methodology*, IDA Document-2779 (Alexandria, VA: Institute for Defense Analyses, September 2002).

Appendix A

INTERVIEW QUESTIONS

A.1 UNITED STATES ATTRIBUTES SURVEY

USERS & USES:

1. In your organization, who currently uses human response models (alone or within a suite of models)? Which models/applications? How often?
2. What questions or issues do the models help answer?
3. How can these models be revised to provide better support?
4. Are there others in your organization that could benefit from these models?
5. What questions or issues could these models help answer?

SCOPE

1. What parameters should the models address?
   a. Agents?
   b. Exposure routes?
   c. Population at risk?
   d. Population demographics?
   e. Medical protection?
   f. Technical detection and surveillance (externally)?
   g. Treatment (externally)?
2. What inputs would you like to specify?
3. For each specific use, what information are you likely to know to input into these models?
   a. Scenario-based planning/training
   b. Current event response
   c. Retrospective Analysis
   d. Research
4. What information should the models output?
5. Do you want to be able to define the output ranges? Do you want to be able to change them?
6. Would you like to see risk/hazard confidence assessments? How would you like to see confidence expressed?
7. Should time be a factor in the model?
   a. Should time be considered as an input?
   b. What times are important to you as the user?
   c. Should time be considered as an output?
   d. What time intervals should outputs be divided into? (Minutes? Hours? Days? Months?)
   e. What time periods are you concerned with for observing casualties? (Acute? Latent? Chronic/protracted?)

METHODOLOGY

1. What methodology should be used in the human response model? Do you have a preference or recommendation?
   a. Probit?
   b. Performance-based?
   c. Toxic load?
   d. Other?
2. How much insight would you require into the underlying methodology? Underlying data?
   a. Completely transparent (algorithms)?
   b. Black box?

APPLICATION/ TOOL

1. What platform(s) should run this application?
2. What interface should this application/tool use?
3. What program(s) should the tool be compatible with?
4. What format(s) should be used to present the outputs?
5. What level of training would you expect to receive for this tool/model?
6. What level of support would your activity require for this tool/model?

Are there others you recommend that we interview on this subject?

A.2 NATO ATTRIBUTES SURVEY

Question A.

1. Which organizations use AmedP-8 now?
2. For what purposes?
3. Are there other potential users who would benefit from changes in the information provided, or if the structure and format of the STANAGs are expanded or changed?

Question B.

1. How is AmedP-8 used?
2. Can AmedP-8 be revised to provide better support in these areas? If so, how?

Question C.

1. Would AmedP-8 benefit from expansion in the scope of its content, by considering additional agents, delivery systems, or tactical scenarios?
2. Plans exist to consider the effects of technical detection and medical protection, where applicable. Are there other considerations such as treatment that should be included?

Question D.

1. Would AmedP-8 benefit from expansion or changes to its approach and methodology? Currently AmedP-8 provides worst case casualty estimates and plans exist to provide a more flexible range of estimates for the specific combination of agents, delivery systems, and tactical scenarios now considered. Are there other areas where users desire greater flexibility?

Question E.

1. Would AmedP-8 benefit from changes in its structure and format?
2. Each STANAG now contains text sections describing background, methodology, followed by several sections of casualty tables. Should tabular format be retained?
3. Would users prefer an electronic tool to assist navigation and specification of cases of interest? Would users prefer to have a methodology available that would allow them to generate their own casualty estimation?

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Appendix B

PROCEEDINGS OF THE CONFERENCE ON DEFINING THE ATTRIBUTES OF A CBRN HUMAN RESPONSE MODEL: CONSENSUS DEVELOPMENT, DECEMBER 4-5, 2006

B. CONFERENCE REPORT FROM *DEFINING THE ATTRIBUTES OF A CBRN HUMAN RESPONSE MODEL*: CONSENSUS DEVELOPMENT CONFERENCE (12/4/2006 AND 12/5/2006)

Institute for Defense Analyses

The purpose of this two-day conference was to develop consensus within the user community regarding the particular attributes that users felt should be included in the next generation of CBRN human response models. Prior to this conference, the IDA study team interviewed current and potential users of human response models within over 30 civilian and military organizations. Their answers were collected, analyzed, and presented at this conference as a starting point for discussions.

The first set of presentations at the conference aimed to familiarize all members of the user community with existing models and tools that dealt with human response or conducted casualty estimation. The second set of presentations, organized into sessions, presented in detail the points of consensus and divergence within the user community regarding specific human response model attributes, as discussed in the interviews. The final briefing reviewed the consensus points developed by participants during the two days of the conference.

The sponsors of the IDA study were the Defense Threat Reduction Agency (Mr. Charles Fromer), the US Army Office of the Surgeon General (MAJ Kevin Hart), and the Department of Health and Human Services (Dr. Peter Highnam).

Dr. Carl Curling, the study lead at IDA, opened the conference by presenting the agenda and objectives.

Introduction to the Use of Human Response Models, Carl Curling, IDA

In this presentation, Dr. Curling discussed the nature and purpose of human response models. In particular, he focused on the various questions that could be asked of human response models and the different ways that these types of models may be used.

Human Response Models for DTRA, Charles Fromer, DTRA (S&T)

Mr. Charles Fromer discussed the role of the Joint Science and Technology Office (JSTO) in the development of the information systems science and technology capability area. He discussed the different areas of technology pull, including battle space management, medical

surveillance modeling and simulation, hazard and environmental modeling transport and dispersion, and chemical and biological warfare effects on operations. He explained that the modeling effort is being sponsored by JSTO and brought back into the tech base in order to develop capability for biological, chemical, and radiation events, and eventually, toxic industrial chemicals and toxic industrial materials (TICs & TIMs). The aim is to maintain use of one edition among departments, so that addressing the same question results in the same answers interdepartmentally, inter-DoD, and internationally.

Human Response Models for HHS, Peter Highnam, HHS (OPHEP)

This presentation briefly introduced the Office of Public Health Emergency Medical Countermeasures (OPHEMC) and their two major activities – Project Bioshield and Avian Influenza planning. Dr. Highnam described his role as responsible for integrating modeling through a shared understanding of the problem and answer. He explained that subject matter experts are engaged at every level and integrated in both the planning and modeling efforts.

Questions were asked regarding the role of the Veterans' Administration in modeling discussions and the responsibility for evacuate/shelter-in-place decisions. Regarding the Pandemic Flu plan, Dr. Highnam indicated that the final version of the plan has not been released yet but is being developed in coordination with DHS and DoD. He described the MIDAS PanFlu model collection effort as a combination of subject matter experts and tools, resulting in realistic, nuanced answers.

Regarding the incorporation of "worried well" populations into the models, Dr. Highnam replied that while it is not an immediate concern for an effectiveness determination, it has come up, particularly with regards to medication distribution discussions.

Human Response Models for NATO, James Smith, Army OTSG

This briefing, presented by James Smith of the Army's Office of the Surgeon General (OTSG), describes OTSG's roles and responsibilities for medical CBRN issues in NATO, the relevant NATO CBRN medical documents (Standardization Agreements (STANAGs) and Allied Publications)), and the role and structure of the NATO Standardization Agency (NSA). The briefing also described in detail NATO's cyclical development and approval process for STANAGs and Allied Publications.

Current Models: Allied Medical Publication-8 (AMedP-8), Julia Burr, IDA

Allied Medical Publication 8, *Medical Planning Guide for the Estimation of NBC Battle Casualties*, is an example of the application of human response models to casualty estimation.

This document, published in nuclear, biological and chemical volumes, provides estimates over time of casualties, fatalities and residual operational strength after NBC attacks against static, tactically deployed units. The guide consists of a series of lookup tables showing the status of unit personnel over time, casualties and fatalities over time, and unit personnel categorized by injury or illness severity.

Current Models: Nuclear, Biological & Chemical Casualty & Resource Estimation Support Tool (NBC-CREST), Gene McClellan, ARA

Dr. McClellan discussed the background or basis of the tool, NBC-CREST and provided an overview of how this tool can be used in casualty estimation and medical planning. The development of NBC-CREST originated at the US Army Office of the Surgeon General, but has since been transitioned to the Defense Threat Reduction Agency's Nuclear Technology Directorate. The purpose of this tool is to "enable advanced planning for medical operations in an NBC environment." ARA is currently working to update NBC-CREST for DTRA.

- Sponsored by Eric Nelson, DTRA
- Some capability to track civilians, but the same data and algorithms were used for them as is used for military, as a "simple bookkeeping of surrounding civilians"
- Plans to include civilians?
    - Yes, but not well formulated
    - Census block data, land scan database were used
    - Takes no account of demographics
- Incorporates DMSB Task Time Treater Files
- Air Force (AF) and Marines have logistics supply numbers.
- Different casualty estimations exist for Army ground forces than for AF pilots.

System to Automate the Benchmark Rate Structure (SABERS), George Kuhn, LMI

LMI is developing a tool, SABERS, for conventional casualty estimation.

- Included discussion about the applicability of Vietnam era concepts for casualty rate estimation to present day operations.

Medical Surveillance System (MSS), Rashid Chotani and Angel Fitzgerald, DTRA

- Models are given TRL levels (3 and 6)
- BMIST—SOF uses it now.

Common User Database (CUD), Ellen Kavanaugh, DMSB

- Version 1 delivered 1 December; it brings together Word and Access.

Joint Operational Effects Federation (JOEF), Dave Hoffman, JOEF APM

- Automated planning tool

- Medical modeling includes human response and resources requirements determination
- Increment 1, before attack, deliberate planning and crisis planning (more M&S)
- Increments 2 and 3, decision support before and after attack (incident response and consequence management for civilian agencies, DoD and coalition forces—more maps, tools, specific mention of CHART tool)
- JOEF examines tasks is a manner similar to the USAF STAFFS model
- JOEF has to interoperate with JEM, JMAT, DMML.

Determining Human Response Model Attributes—Session 1: Interview Process, Carl Curling, IDA

In this presentation, Dr. Curling discussed the method or process used by IDA to go about determining human response model attributes. He briefly discussed the status of current human response models with the human response model in AMedP-8 as a specific example. He discussed the drivers behind the task for each of the three sponsors—HHS, DTRA, and Army OTSG. He described the interview process for gathering attribute information from current and potential human response model users, and provided a summary of the results of this process.

- It was noted in the discussion that "human response" as defined in this context is sometimes referred to as "human effects"
- A request was made to add capability developers (e.g., JCIDS) to "users and uses" list.

Determining Human Response Model Attributes—Session 2: USERS & USES Attributes, Deena Disraelly, IDA

Ms. Disraelly presented the results of the attribute collection interview process pertaining to the Users and Uses of human response models. Various comments and suggestions were made by participants:

- The model users listed in slide 3 are also applicable to the VA.
- There was general consensus that the military operational users (slide 6) can be summarized by saying "command and flag level staffs." In particular, attendees also recommended the incorporation of J-4.
- There was a suggestion that WMD Civil Support Teams be added to the list of users (POC offered by Ellen Kavanagh). Also suggested was the incorporation of DSCA (the Defense Security Cooperation Agency) and Dr. Tom Hopkins at NDU.
- There were suggestions to add to the list of civilian users the following organizations: FBI; VA (health, policy, and police divisions); Metropolitan Medical Response System; Civil Engineering.
- There was agreement regarding the list of current models/applications that are used.
- The lack of guidance (or perhaps discipline) at the interagency level or even DoD level for a specific model to be used consistently was noted. Furthermore, the importance of training and awareness for existing and new models was stressed.
- Military operational users reach back to the experts because either they don't have the expertise themselves, or because that's what they've been told to do.

- Some other applications were mentioned: DSP for supply estimation; TML+ used to model capacity in Navy/Marines.
- Some models are being used in the military for training/exercises.
- Models can be improved to consider the effect of countermeasures and treatment.
- Mr. Mahoney (CDC) noted that his group also mentioned natural disasters during the interview process.
- There was lengthy discussion about the scope of human response models in this task. Particularly, are natural disasters within the scope? Is resource determination with the scope?
- There was discussion about some of the responses provided during the interviews (e.g., language issues, hurricanes) and how they relate to human response modeling.
- There was a comment that in one interview, it took time for participants to understand that the questions pertained specifically to human response, not the resource modeling aspects, etc. Other groups may have had similar difficulty and as a result indicated attributes which should not be in the scope of human response models.
- In the viewpoint of the IDA study team, not all users can talk directly about the human response models, since they may not be knowledgeable about them, but what we can do as interviewers is understand their modeling needs, which may include understanding the modeling they do (and want to do) and issues of concern to them, which will include areas outside the direct scope of human response modeling. This information helps us understand them as users and their modeling needs, which we can then relate back to the human response component.

Determining Human Response Model Attributes—Session 3: SCOPE Attributes-INPUTS, Carl Curling, IDA

Dr. Curling presented the results of the attribute collection interview process pertaining to the Inputs for human response models.

- There was discussion and disagreement regarding the inclusion of certain categories within the Agents parameter:
    - Should pandemic influenza be included in this task? (arguments were made for and against this)
    - Should naturally occurring and emerging infectious diseases be included?
    - Should explosives be included? (the general consensus appeared to be "no")
    - Should hurricanes and other disasters be within the scope of CBRN human response models? (the general consensus here seemed to be "no")
- For the Exposure Routes parameter, participants agreed that the particular routes to be included in the model depended on agent, but should include more than just inhalation. Several additional points were raised:
    - The exposure routes are agent dependent (group generally agreed to this) and recommend prioritization of exposure route by agent.
    - Recommend the inclusion of "combined" as an exposure route
    - One participant stressed that EPA is no longer trying to pursue certain models (i.e. dermal) due to lack of valid data.

- Psychological/ “worried well” aspect is a human response and therefore should be within the scope of human response models.
- There was agreement that the Population at Risk parameter be dynamic, scalable, and differentiable.
- There was discussion on the importance of demographics and what demographics were significant; attendees generally agreed that they want to be able to differentiate certain groups in the population, but could not agree on which groups should be differentiable.
- There was a recommendation that the group of model users help create a forum for prioritization and determination of data gaps.
- There was agreement that in general parameters should be included where data is available.
- For Medical Protection, prioritize countermeasures that are FDA-approved.
- Attendees agreed to the consensus point that medical protection be modeled for all available items, and that associated behavior and compliance must also be considered. They stressed, however, that data may not exist, and that it is important to recognize this in the model.
- Attendees agreed to the consensus point that technical detection and syndromic surveillance should be included when applicable.
- Concern was raised regarding HIPAA and the inclusion of surveillance and medical detection into the model. Surveillance and medical detection results are inputs into the models, but the systems remain separate from the models, thus mitigating privacy concerns.
- One attendee raised questions regarding “recovery as an endpoint.” Medical models allow for a modifiable definition of recovered, whereas in operational models that level is usually a set value. Ideas for the appropriate definitions of “recovery” could be passed on to DMSB for inclusion in Task Time Treater Files.

Determining Human Response Model Attributes—Session 4: SCOPE Attributes- OUPUTS & TIME, Lusine Danakian, IDA

Ms. Danakian presented the results of the attribute collection interview process pertaining to the Outputs and consideration of Time in human response models. Several comments and suggestions were made by participants:

- A valid term must be used instead of “worried well.”
    - The suggestion was made to use “concerned public” or “highly sensitized population.”
    - In the report, it should be noted that “worried well” was mentioned repeatedly, even though participants knew the term was no longer valid.
- Use “performance capability” consistently instead of “performance level.”
- As an additional output category, include “location where people will report (clinic, hospital, stadium, etc.)”; this may help determine triage resource requirements.
- Susceptibility/ vaccination status may be an additional filter for casualty type.
- During the discussion of treatment requirements, the suggestion was made to tie in patient unit with code; additionally, exposure groups were recommended as a basis for grouping patients.

- Participants discussed the appropriateness of using “first-responders” as a term to include the military medical staff and installation response force.
- Participants discussed the necessity for incorporating hazard/risk confidence assessments into the model. The question was asked whether users are willing to input their uncertainty in the inputs. The answer was both yes and no, depending on the user. The method of expressing risk was also discussed – “Commanders don’t want numbers; they want a low risk, a moderate risk, or a high risk.” Recommendations were made to use a SME panel to help determine confidence levels and to include confidence level expression as a user-selectable option.
- Both time and time duration need to be considered in the models.
- There was discussion about “chronic” and “delayed” time periods, and the need for defining these terms and many others up-front in the final report of this study (use “protracted” rather than “delayed”). Participants noted that in toxicology, “chronic” effects are defined as effects lasting seven years or longer.

Determining Human Response Model Attributes—Session 5: METHODOLOGY & TOOL Attributes, Julia Burr, IDA

Ms. Burr presented the results of the attribute collection interview process pertaining to the Methodology of human response models and characteristics of a Tool for these models. There was general agreement with the consensus points presented within these two topics. Several comments and suggestions were made by participants:

- Combined effects need to be included into methodology.
- Documentation should be readily available for all aspects of the methodology.
- Criteria need to be established for the “well-documented” attribute on the list.
- Underlying algorithms should be made available to interested users.
- Default scenarios should be included as a training tool.
- Outputs should be saved in a repository by the tool (lifecycle management of outputs) to be able to recreate results.

Determining Human Response Model Attributes—Session 6: Way Ahead, Carl Curling, IDA

Dr. Curling discussed the way ahead for this study. He presented lists of military and civilian user community representative that have been interviewed by the IDA study team to date, and those that will be potentially interviewed in December and January. He also presented a timeline for the continuation and completion of the study. Dr. Curling requested input from conference attendees for a prioritization for organizations that had not been interviewed to date. The group attempted to prioritize the military list only, since the civilian community was not well-represented at the conference:

- Military first priorities include CSTs and Marine Corps senior operating force surgeon at one of our interviews.

- During the meeting, LtCol Gillen, USAF, scheduled a Model Attributes Discussion with representatives of the Air Force.
- Additional priority should be given to the following organizations: NORTHCOM, STRATCOM, and TRADOC.
- Discussion occurred about whether NDU and school houses, customers of the product, should be considered high priority interview candidates
    - TRADOC published a report that the Army did not concur with. Need to get them engaged in this effort, too.
    - Some others thought that TRADOC shouldn't be at the top of the priorities list
- The final report of the study should include a comment about the significance of the latest agent fate within the modeling process, so that it could be obtained from DTRA.

Appendix C

US INTERVIEWEES AND INTERVIEW NOTES

Appendix C available on request from the sponsor organizations.

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APPENDIX D

NATO SURVEY RESPONSES

Appendix D available on request from the sponsor organizations.

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APPENDIX E

ANALYSIS OF INTERVIEW RESPONSES

APPENDIX E. CONTENTS

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E.1. DEFINITIONS

The following definitions apply to this paper and to the discussions and interviews conducted throughout the course of this study.

Acute effect

An adverse or undesirable effect that is manifested within a relatively short time interval ranging from almost immediately to within several days following exposure.[7]

Acute exposure

Exposure over a brief period of time (generally less than 24 h). Often it is considered to be a single exposure (or dose) but may consist of repeated exposures within a short time period.[8]

Attribute

A characteristic or property; in this context, a characteristic of human response models.

Casualty

A casualty is defined in military terms as someone whose performance (or ability to perform a required task) has degraded to the point where task accomplishment is nearly impossible. Individuals become casualties or seek medical attention as a result of the symptoms they exhibit. The definition of a casualty – or a prospective patient – may be user-defined in the proposed human response models.

Chronic effect

A permanent or lasting adverse effect that is manifested after exposure to a toxicant.[9]

Chronic exposure

Exposures (either repeated or continuous) over a long (greater than 3 months) period of time.[10]

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7 *Principles of Toxicology: Environmental and Industrial Applications, Second Edition*, Edited by Phillip L. Williams, Robert C. James, and Stephen M. Roberts. John Wiley & Sons, Inc., 2000, p. 4.

8 *Principles of Toxicology: Environmental and Industrial Applications, Second Edition*, Edited by Phillip L. Williams, Robert C. James, and Stephen M. Roberts. John Wiley & Sons, Inc., 2000, p. 4.

9 *Principles of Toxicology: Environmental and Industrial Applications, Second Edition*, Edited by Phillip L. Williams, Robert C. James, and Stephen M. Roberts. John Wiley & Sons, Inc., 2000, p. 4.

Civilian Organizations

For the purposes of this study civilian organizations are all non-military organizations, including federal, local, and national lab entities.

Delayed or latent effect

An adverse or undesirable effect appearing some length of time after the initiation and/or cessation of exposure to the toxicant.[11]

Exposure

To cause an adverse effect, a toxicant must first come into contact with an organism;[12] exposure is the time-integrated environmental concentration to which an individual is subjected.

Human response model

Also known as a casualty estimation model, a human response model is usually one component of a larger suite of models. For the purposes of this study, a human response model is used to estimate the status over time of personnel exposed to some Chemical, Biological, Radiological, or Nuclear (CBRN) event. The model estimates the number of people who may be expected to require medical treatment, as well as the number of anticipated fatalities due to the insult.

Medical Countermeasures

Medical measures taken to provide protection against disease by intervening with or counteracting the onset and/or progression of disease. Medical countermeasures effective against biological agents include certain medical procedures, pre- or post-exposure use of antibiotics, antivirals, immunoglobulins/antitoxins, and active immunoprophylaxis by immunization. In the context of this study, medical countermeasures administered before symptom onset as preventive measures are referred to as prophylaxes, and those administered after symptom onset for medical or surgical management of a patient are referred to as treatments.

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[10] *Principles of Toxicology: Environmental and Industrial Applications*, *Second Edition*, Edited by Phillip L. Williams, Robert C. James, and Stephen M. Roberts. John Wiley & Sons, Inc., 2000, p. 4.

[11] *Principles of Toxicology: Environmental and Industrial Applications*, *Second Edition*, Edited by Phillip L. Williams, Robert C. James, and Stephen M. Roberts. John Wiley & Sons, Inc., 2000, p. 5.

[12] *Principles of Toxicology: Environmental and Industrial Applications*, *Second Edition*, Edited by Phillip L. Williams, Robert C. James, and Stephen M. Roberts. John Wiley & Sons, Inc., 2000, p. 4.

Medical Protection

Medical countermeasures administered before the onset of symptoms to provide protection against illness or death; also called prophylaxes.

Military – Operational Organizations

For the purposes of this study, operational units are units which were long-term deployable to or permanently stationed in an operating area.

Military – Support Organizations

For the purposes of this study, support units are all other military organizations, but encompassed stateside units in particular, including schools, research organizations, and other military agencies and offices.

Performance

The ability of an individual to carry out a specific task after exposure to a toxicant.

Probit slope

The slope of the dose-response curve when the x-axis is expressed as the logarithm of the administered (or received) dose and the y-axis is expressed as probits (probability units) of response.

Prophylaxes

Medical countermeasures administered before the onset of symptoms to provide protection against illness or death.

Psychosomatic casualty

One who has a disorder having physical symptoms but originating from mental or emotional causes.

Return-to-duty

An individual who was a casualty but has recovered and, as a result, leaves the medical system and reports back to duty.

Route of exposure

The means by which an organism comes into contact with the substance.[13]

Toxicant

Any substance that causes a harmful or adverse affect when in contact with a living organism at a sufficiently high concentration.[14]

Toxin

Any toxicant produced by an organism.[15]

Treatment

The medical or surgical management of a patient after the onset of symptoms.

"Worried well"

This term generally refers to people who are worried (or convinced) that they have a particular disease, even though they are physically well (in other words, they do not actually have the disease). "Worried well" is not a formal psychiatric term, but this term is in common use among many health professionals and among the general population.[16] We use the term in this study because many interviewees referred to it during the course of this study.

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[13] *Principles of Toxicology: Environmental and Industrial Applications, Second Edition*, Edited by Phillip L. Williams, Robert C. James, and Stephen M. Roberts. John Wiley & Sons, Inc., 2000, p. 4.

[14] *Principles of Toxicology: Environmental and Industrial Applications, Second Edition*, Edited by Phillip L. Williams, Robert C. James, and Stephen M. Roberts. John Wiley & Sons, Inc., 2000, p. 5.

[15] *Principles of Toxicology: Environmental and Industrial Applications, Second Edition*, Edited by Phillip L. Williams, Robert C. James, and Stephen M. Roberts. John Wiley & Sons, Inc., 2000, p. 5.

[16] http://www.thebody.com/sowadsky/worried.html, accessed April 4, 2007.

E.2. STUDY METHODOLOGY

OBJECTIVES

The primary objective of this study is to develop a consensus on the attributes that a coordinated human response model should have. Secondary objectives which this study will seek to achieve include identifying areas where community views will continue to diverge, by choice or necessity, providing an opportunity for communication among the various members of the military and civilian communities, and considering alternative paths for implementation of a new human response model within one or more tools.

PROJECT IMPETUS

Each of this study's sponsoring organizations, OTSG, JSTO, and OPHEMC, had begun independent efforts to define the attributes of human response models required to support their organizational responsibilities. Each office determined that new models were needed to address threats and exposure scenarios not currently considered by existing models. To support the development of human response models useful across the spectrum of applications, these organizations tasked IDA with defining a consensus set of desired model attributes.

PROJECT SCOPE

The NATO Alliance publishes Allied Medical Publication 8 "Medical Planning Guide of NBC Battle Casualties" (AMedP-8), a document which provides estimates of casualties resulting from the use of Nuclear, Biological, and Chemical (NBC) weapons on a battlefield. While accepting of the current manual on the estimation of NBC casualties, NATO members desire to update the models and increase the utility of AMedP-8. The new version of AMedP-8 must address a wide range of military operations, for units from squads to an Allied Task Force. NATO Allies have also expanded the scope of the desired AMedP-8 to address classical NBC warfare agents, toxic industrial chemical and materials, radiation dispersal devices, pandemic influenza, and other emerging threats. The Office of the US Army Surgeon General (OTSG) is the custodian of AMedP-8, and is responsible for preparing the draft revisions of AMedP-8.

The Joint Science and Technology Office (JSTO) of the Defense Threat Reduction Agency (DTRA) is supporting the development of the Joint Operational Effects Federation (JOEF) as the next generation of US models which estimate the operational impact of CBRN agents. Throughout the developer and user communities, it is recognized that JOEF must incorporate a human response model that is accredited by DoD and accepted by the user

community. The JOEF program establishes the acquisition parameters for development of a new suite of tools, without clearly articulating the attributes of the human response model desired by the user community.

The Office of Public Health Emergency Medical Countermeasures (OPHEMC) in the Department of Health and Human Services (HHS) is tasked with planning for the medical response to the domestic terrorism use of CBRN agents, and identifying the types and amounts of material to be procured through Project BioShield to support this response. The direction to HHS to develop a stockpile of material for national response to CBRN disasters implies the requirement for a nationally accepted model of civilian response to CBRN events that is acceptable to cities, states, and the federal government.

INTERVIEW PROCESS

This study used a series of interviews of multiple agencies across the potential user community to define the desired CBRN human response model attributes. The questions were posed to the NATO nations and Partnership for Peace allies by correspondence – all other interviews were conducted in person by IDA personnel. The interviewees included almost 200 personnel from more than sixty military and civilian agencies, to include the Joint Staff and Service and Combatant Commanders' staffs, various military and civilian research and training institutes, as well as numerous federal, state, and local civilian agencies. The questions were divided into six broad topics:

- Users and uses
- Inputs known to the users
- Output desired by the users
- Time dimensions appropriate to the task
- Model methodologies to be considered
- Tool and application properties desired by the user.

(The complete list of questions can be found in APPENDIX A.)

These questions were selected to address several points of interest to the sponsors of this study. The first set of questions, "Users and Uses," defines the scope of applications that CBRN human response models are expected to meet. "Inputs" helps to prescribe what information should be used as model inputs. "Output," Time," and "Methodologies" each assist in describing significant attributes of the CBRN Human Response models. "Tool and Application" questions, while not dealing directly with the models themselves, address oft-raised concerns that the model users have regarding the applications that implement the model.

INTERVIEWEES

While more than thirty countries were contacted through the NATO Chemical, Biological, Radiological and Nuclear (CBRN) Working Group (CBRNMedWG), only five provided written responses to the questions posed to them: Canada, Germany, Great Britain, the Netherlands, and the United States. In order to address this task more broadly, and in more depth, IDA identified domestic US governmental agencies that used CBRN human response models. These agencies included federal, state, and local agencies, and included military and civilian activities. *(The complete list of organizations interviewed can be found in Table E.1.)* Generally, a team of two persons from IDA, an interviewer and recorder, would travel to the office of the agency of interest. The interviewer would request a short briefing on the roles and responsibilities of the interviewees in the room, and provide a short briefing on the model attributes task and IDA's role in this task. The remainder of the interview, totaling normally 3-4 hours, would be devoted to an open discussion on the questions on each topic. Not including the NATO correspondence, these interviews were carried out between July 2006, and January 2007, with twenty-eight site visits which included 165 personnel. A NATO visit with ACT was conducted in April 2007.

Table E.1. Participant Organizations

ACO/ACT	COGH/OGPSS	LA County PH	PHMSA
AFIOH	COMPACFLT	LANL	RIVGRU ONE
AFMOA/SGX	COTPER	LAWA	RSO Norfolk
AFRL	C2F	MARFORCOM	Sandia Nat'l Lab
AFRRI	Denver Envir. Health	NAVMEDCEN SD	SD Emerg Prep
AFSGR	DenverFD	NECC	SOCPAC
AMEDDC&S	Denver OEM	NEPMU-5	SWMI
ANGRC	DenverPD	NHR	Third Army
ARCENT	DOT	NHTSA	3rd Fleet
Army OTSG	DTRA	NMCSD	13 AF
ARA	ECBC	NMCO/RSO Norfolk	USANCA
ASBP	FAA	NORAD	USAFSAM
Boston EMS	FEMA	NORTHCOM	USAMRICD
BPHC	FFC	NSW	USAMRIID
BUMED	JFCOM	NYC DOT	USARPAC
CASS	JRO	NYC OEM	USFORSCOM
CCID/NCID	JTF-CS	NYPD	USUHS
CENTCOM	LA City Emerg Prep	NY/NJ Intel	
CHPPM	LA County DMH	PACOM	

It should be noted that in the following chapters, organizational viewpoints are expressed in terms of interview sites. Although seventy-four separate U.S. organizations were included in the interview process (sometimes with a single participant and sometimes with multiple participants from the same organization), any given interview might include one or more organizations. Due to the difficulty in identifying and capturing the organizational affiliation of individuals during the often rapid exchange of views and responses during the interviews, responses were tracked and recorded by interview site alone. The exception to this general rule occurred during two multi-organizational site visits, where responses were recorded by organization. As a result, in the following chapters, responses are analyzed for a total of thirty-two different organizations/sites.

COLLECTION AND ANALYSIS OF RESPONSES

Following the collection of the responses to these questions, IDA analyzed them to identify the points of consensus representative of the potential users of human response models. IDA also identified issues on which the organizations diverged in their views.

Although the interviewees were originally divided into three groups ("NATO," "US Military" and "US Civilian"), it soon became clear that there were differences in responses among organizations within each of these groups, as well as similarities among organizational responses across them. As IDA progressed in the analysis of interview responses, "NATO" and "US Military" were combined and separated into the groups "military operational" and "military support." Military operational units were defined as units which were long-term deployable to or permanently stationed in an operating area. Military support were all other organizations, but encompassed stateside units in particular, including schools, research organizations, and other military agencies and offices. For site visits which included both military operational and support units, responses were organized into either military operational or military support based on the primary function of the host organization. The civilian responses, which included federal, local, and national lab replies, while bearing some similarities to both the military operational and military support were regarded as sufficiently unique to require maintaining them in a discrete analytical bin.

Organizational responses within these groups were compared for consensus and divergence. In the remainder of the report, answers are reported as "Consensus," "Divergence," or "Amplifying Information." A "Consensus" response is one that was common to many respondents who answered that particular question across the whole spectrum of interviewees; the consensus may be represented by a series of responses as well as by a single response. A "Divergent" response was an organizational response which differed, but was not necessarily opposed to, the consensus or may include the representative range of responses to questions for which IDA could find no consensus. "Amplifying Information" is presented to provide additional background on answers provided either by the group as a whole or by particular community. For ease and clarity, the number of responses to each question, as well as the number of respondents who agreed with each particular answer, is provided. Finally, responses were further assessed to try and identify any overarching attributes desired by the interviewees.

It should be noted that lack of response to a question may indicate that the participant organization did not have input but may also indicate that the question was not asked or was asked in such a way as to yield a different answer. Omission does not necessarily indicate that the response was unimportant to the interviewee but rather that it may not have been considered by the respondents who attended the meeting or that it may not have been captured by the interviewers themselves.

REPORT AND RECOMMENDATIONS

The results of analysis described above are provided in this report. These are intended to be used by the sponsors of this task (OTSG, DTRA, HHS) as guidance for the development of new and existing CBRN Human Response models. It is not expected that every attribute identified in this study will be available in every tool or application which uses CBRN Human Response models. It can reasonably be expected, however, that overarching attributes that were common to all of the interviewees would be present in all of the applications, and that those attributes which were specifically desired by particular users, or for particular uses, would be addressed in those tools designed specifically for those users or uses.

E.3. USERS & USES

SUB-TASK OBJECTIVE – USERS & USES

This section identifies current and potential users of and uses for CBRN Human Response Models.

U.S. QUESTIONS

Six questions were asked to assess both the current and potential users of and uses for CBRN Human Response Models. Participants were asked who in their organization currently uses or could benefit from the use of models. They were also asked which models are currently in use, what questions the models help answer and which additional questions new models might answer. Additionally, they were asked how the current models could be improved so that they might be considered more useful to current users. The questions and associated answers are shown below.

It should be noted that for these questions, there are general areas of consensus – users with similar aims or questions – but, because the questions regard model employment and not requirements, no answers are identified as divergent. Additional or amplifying information, however, where available, is included.

U.S. Question 1:
In your organization, who currently uses human response models (either alone or within a suite of models)?

Of the thirty-two organizations/sites tallied, twenty-nine expressed an opinion or provided an answer to this question. It is important to note that although several of the organizations polled named internal and external model users, as will become clear in the next question, many were not clear on the definition of human response models or the type of models in use in their organization.

Consensus

What's of particular interest regarding this question is that although the names for the individuals and organizations using modeling varies from one interviewee to the next, users tend to fall into a limited number of categories – surgeons, medical personnel and public health (13 of 29); planners (13 of 29); and operations, incident analysis, and emergency managers (18 of 29). A few users (6 of 29) noted that their organization either does not currently use models or uses

model results produced by a single member of the organization or an external organization. Other model users included first responder organizations (5 of 29), personnel managers (2 of 29) and research and general modelers (5 of 29).

- Many organizations use models (27 of 29). Those users include:
  - Operations, Incident analysis and Emergency managers (18 of 29)
  - Planners – Logistics, Operations, Personnel, Medical, etc (13 of 29)
  - Surgeons, Medical personnel, and Public health (13 of 29)
  - Laboratories and research centers (5 of 29)
  - First responder organizations and Civil Support Teams (5 of 29)
- Sample organizations where models are used include:
  - Combatant Commands
  - Marine Corps Manpower Plans and Policy Division
  - Navy Radiation Health
  - United States Army Medical Research Institutes for Infectious Diseases and Chemical Defense
  - Defense Threat Reduction Agency
  - United States Army Nuclear and Chemical Agency
  - Department of Transportation
  - National Institute for Occupational Safety and Healthy
  - National Labs, including Los Alamos and Sandia
  - Local Public & Mental Health Departments
  - Local Emergency Management Organizations
  - Local Fire, Police and Emergency Medical Services

U.S. Question 2:
Are there others in your organization that could benefit from these models?

Of the thirty-two organizations/sites tallied, only twenty expressed an opinion or provided an answer to this question.

Consensus

The organizational users who were suggested as possible users who would obtain benefit from models were similar to those referenced in question 1. For example, additional potential users included: surgeons, medical personnel and public health (5 of 20); planners (8 of 20); and operations, incident analysis, and emergency managers (8 of 20). In this discussion, interviewees added trainers and exercise developers (3 of 20) and researchers (3 of 20) as additional categories of potential users.

In contrast to the earlier question, multiple interviewees also raised the point that they either would not use the model or do not have the resources to run the model (3 of 20).

- Many additional organizational users could benefit from the use of models (17 of 20). Those potential users include:
  - Surgeons, Medical personnel, and Public health (5 of 20)

- Planners – Logistics, Operations, Personnel, Medical, etc (8 of 20)
- Operations, Incident analysis and Emergency managers (8 of 20)
- Laboratories and research centers (3 of 20)
- Trainers and Exercise developers (3 of 20)
- First responder organizations and Civil Support Teams (5 of 20)

In addition, users provided information on other organizations, agencies and groups that might benefit from the use of models. It is important to note that some of the users recommended below are also included on the list of current users. This list is the recommendations of those who were present in the interviews only. It is not intended to imply that these users are not currently using human response models; it is only intended to add other potential users that interview participants noted in their discussions.

- Also suggested were:
  - Public Affairs
  - Mortuary Affairs
  - Terrorism/Early Warning cells and Intelligence Organizations
  - National Guard
  - Environmental and Operational health experts
  - Doctrine developers
  - Civil affairs and Security organizations
  - Local Departments of Transportation
  - Hazardous Materials personnel
  - Hospitals
  - Police and Fire Departments

U.S. Question 3:
Which models/ applications do they use? How often?

Thirty of the thirty-two organizations/sites tallied expressed an opinion or provided an answer to this question.

Consensus

Although thirty of the thirty-two organizations/sites tallied knew that models were used within their own organization, many were unfamiliar with the term “human response” model. Some suspected that the models they were using were human response models, even when they were not; others were using human response models but were not aware that the models they were using provided human response capability.

As a result, the models that were listed by the interviewees as being in-use include multiple different types of models: plume models and the associated casualty estimation tools (14 of 30); probit models (6 of 30); pandemic and epidemic models (7 of 30); epidemiological models (7 of 30); resource tracking and logistics models (6 of 30); and rules of thumb (11 of 30).

- Models that are used with some regularity include:
  - Plume models and the associated casualty estimation tools are used during exercises and planning (i.e. HPAC, CREST, JCATS, etc) (14 of 30)
    - Participants also listed VLSTRACK, ALOHA, CAMEO, and NARAC models among those commonly in use
  - Probit models are used on a limited basis, and usually only as incorporated into other models (6 of 30 – NOTE: this number may be skewed low due to a lack of participant familiarity with the methodologies underlying existing models)
  - Pandemic and Epidemic models have been used to estimate casualties from influenza and to track emerging infectious diseases (7 of 30)
    - The Department of Health and Human Services' FluSurge has been used for planning and casualty estimation (3 of 30)
    - BioWatch, BioNet, Biological Warning and Incident Characterization, Global Emerging Infectious Surveillance, and local/laboratory models have been used to track disease spread (4 of 30)
  - Models not directly related to CBRN, including epidemiological models, resource tracking models, and logistics models (i.e. MAT) are also used (30 noted instances)
    - DOORS, Epi-Cast, and MAT were mentioned as three examples of non-CBRN models currently in use
- Rules of thumb, best guess, and estimation are commonly used (11 of 30)
  - These may be based on Subject Matter Experts; Center for Disease Control, World Health Organization, or Department of Defense guidelines; military documents; historical experience; or any other number of sources
- At least four of the organizations noted that models are used, but infrequently; four other interviewees were unaware of which, if any, models are being used within their organizations (8 of 30)
  - Frequency of usage is often a function of accessibility and ease of use
  - Users also noted lack of transparency, inapplicability and inaccuracies as reasons models are not used more frequently

Amplifying Information

Military Operational Organizations

Of the nine military operational organizations who responded to this question, all are doing some modeling, but many are relying on rules of thumb or internally developed (or "homegrown") models, for example the Marine Corps CASEST (casualty estimation) tool or 3rd Fleet's homegrown casualty and resource estimation tool developed in conjunction with local universities. Two organizations pointed out that they rely on DTRA to provide modeling capability; participants also referenced call back assistance to the National Labs and FRMAC.

Further, the participants indicated that they have somewhat of a disconnect because they aren't expected to focus on operations in a CBRN environment even though each is expected to plan for and be able to operate in such an environment. One stated explicitly what many

indicated they believed to be true – the current casualty and resource estimation tools in use by the Combatant Commands don't seem to incorporate good CBRN casualty estimation models.

Military Support Organizations

All thirteen of the surveyed military support organizations responded to this question. Three were unaware of which, if any, models were being used within their organizations. Four noted that their modeling is done by other organizations. Two cited the Defense Threat Reduction Agency as their reachback and modeling source. One indicated that much of their modeling is conducted through contracts with federally funded research and development centers outside the Department of Defense. One reported that their modeling is based solely on casualty estimates provided by the Combatant Commands; they were unsure of what tools the CoComs used to derive those estimates.

Civilian Organizations

Of the civilian organizations interviewed, eight responded to this question. Two expressed frustration with current models – while they know that there are models for casualty estimation and resource tracking, they are unaware of what exists or how to obtain access to the models. Additionally, although they anticipate being required to use models designated by federal entities, at least one organization is developing its own models to account for local variations, concerns, and plans until the national models become widely available.

U.S. Question 4:
What questions or issues do the models help answer?

This question was added after the initial interviews were conducted. As a result, it was only asked of twenty-nine organizations/sites; of those, twenty-five provided an answer to this question.

Consensus

Participants divided their anticipated model use into focusing on two sets of questions – those that occur before an event, and thus help prepare for it; and those that occur either in the course of or following an event and assist in the response to or analysis of the event. In Figure 1, the circles represent the types of questions that participants would anticipate using the model to help answer, including planning (20 of 25), training and exercises (9 of 25), resource estimation (at least 8 of 25), event/outcome prediction (8 of 25), policy or concept of operations support (approximately 5 of 25), retrospective analysis and analysis of alternatives (4 of 25), and epidemiological or reverse tracking (discussed but not mentioned explicitly as an answer to this question). The ovals inside each circle indicate the types of models that users anticipated utilizing to help answer the overarching questions.

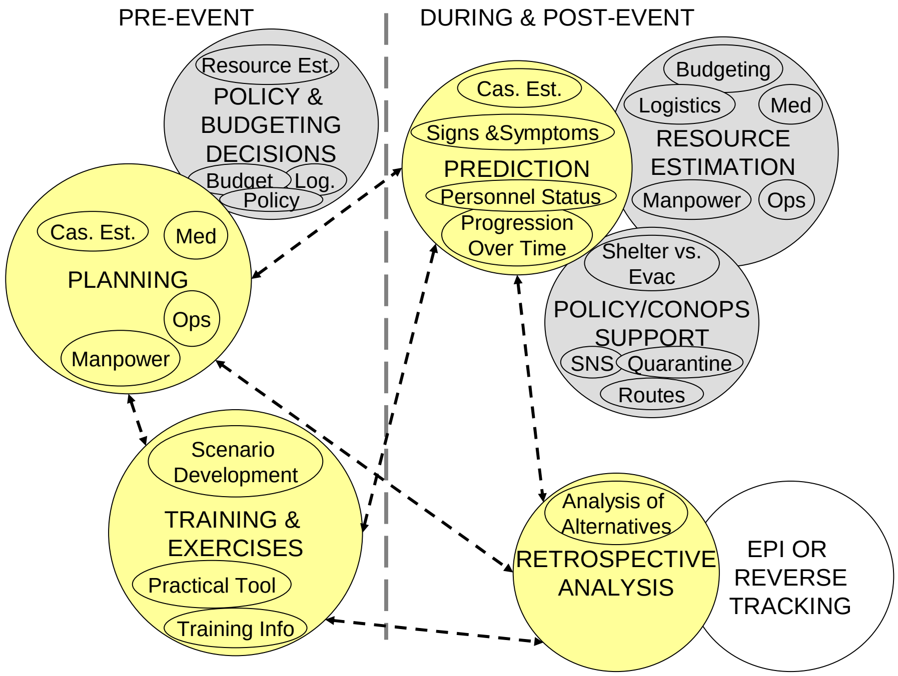

Figure E.1. Pre-, During, and Post-Event Questions Models Aid in Answering

The above figure shows many of the different questions that models could potentially be used to answer that were discussed by the interviewees. These were grouped by type. For example, there are many planning uses of the model – casualty estimation, medical planning, manpower requirement estimation, and operations planning, among possible others. Similarly, a model might be used for training and exercise purposes to help develop training, drill and exercise scenarios; it might be used during the drill or exercise as a tool; and it might be used to help develop information that will be used in training materials.

The yellow circles show the primary questions that a human response model might be used to answer – the criteria and requirements for these models are what were discussed later in the interviews with the participants. The grey circles show additional questions that might be answered by adding a supplementary model or module onto a human response model. For example, by adding a resource estimation tool onto a human response model, questions regarding budget, logistics requirements, and materials might be answered. The single white circle is a question and model use that interviewees discussed and a process that might be conducted as part of a retrospective analysis, but one which might require a different methodology or process than those utilized in the human response models themselves.

It should be noted that the divisions and representation above were imposed on the information provided by the participants; they did not suggest this representation themselves. From the interviewees' responses, it is clear that "What you want to get out depends on who you are." The questions users posed to tools using human response models include:

- Casualty estimation
  - How many casualties? How many need to be treated and/or evacuated?
  - What are symptoms over time?
- Planning
  - Could medical, operational, logistics, and manpower plans be derived from casualty and exposure estimates?
- Training and exercise employment
  - Could facilitate the development of realistic scenarios?
  - Would provide a tool for use in drill events?
- Policy and political decisions
  - Answer questions raised by the government or the within the community
  - Set criteria for exposure limits
  - Support hazard avoidance (occupational hazard)
- Resource determination
- Budgeting decisions

U.S. Question 5:
How can these models be revised to provide better support?

This question was added after the initial interviews were conducted. As a result, it was only asked of twenty-nine organizations/sites; of those, twenty-three suggested possible improvements to the models. Note that these suggestions are listed below for completeness; they are discussed in more detail in later chapters of this report.

Consensus

Interviewees suggested several ways that models could be improved to make them easier to use and more likely to be used. Some of these suggestions may seem obvious, however, they are noted in particular because multiple users felt the same need for improvements existed.

- Model MUST be EASY to use (7 of 23, but many more stated this at other points in the interview as well)
  - Models should be compatible with other tools and modules already in use (i.e. HPAC, CATS, Emergency Management Tools, GIS, etc)
- Models must be credible, transparent, and include a method for assessing results (9 of 23)
  - Models must (or should) be accredited
  - Assumptions of current models clearly stated, reasonable, and understandable
  - Outputs must be clear and presented in a format that is understandable to the user
- Model must address users questions (7 of 23)
  - Scale of event
  - Time frame

    - Realistic, variable populations (i.e. incorporate local population data)
    - Casualty categories (including worried well)
    - Robust and flexible to address changing scenarios, including certain non-WMD (i.e. explosives, contagious diseases)
    - Logistics questions
    - Modeling to generate special equipment requirements (surgery, ventilators)
- Models should be publicly available and/or standardized and training should be provided (4 of 23)
- Best possible data should be used in the models (4 of 23)
- Model must use a common terminology and accepted definitions (3 of 23)
    - Incorporate a non-military/adjustable definition of casualty

Divergence

Civilian Organizations

Of the civilian organizations/sites tallied, all nine responded to this question. Three suggested that special needs populations needed to be accounted for in current models. Within the special needs populations, they included “Worried Well”, psychological and behavioral casualties, those with physical, mental, or medical facilitation requirements, and the elderly and infirm.

Although already noted, the civilian respondents also stressed the importance of including local information and accounting for time variation of that population – for example, a city’s population may increase by as much as ten times during working hours and increase by orders of magnitude during sporting events or major holiday celebrations.

U.S. Question 6:
What questions or issues could these models help answer?

Of the thirty-two organizations/sites tallied, twenty-seven provided an answer to this question.

Consensus

As above in question 4, participants’ responses may be divided into particular types of model use. Because these responses were provided primarily as a basis for moving forward with the remaining discussion, numbers of respondents for each answer will not be provided.

It may be useful to note that many of the potential uses listed below are also noted as current uses of the models or questions that the models help answer. This list documents the potential human response model uses as they were identified by the interview participants. It is not intended to imply that human response models are not already in use for these very purposes; in fact, as noted in questions 3 and 4 above, models are already in use to aid in many of these activities.

- Analysis of alternatives
  - Know what the outcome needs to be but don't always know if the plan will work – use models as a tool to test/validate
  - Do we change the interventions if we have single instances of disease vs. large numbers of people sick with the disease? How?
- Civilian casualty estimation
- Current event response
- Forensic, epidemiological and retrospective analysis
  - Know what it was and where it spread – where did it come from?
- Planning
  - Logistics, medical, personnel
  - How severe are the casualties? Where are they clustered?
  - Personal protective equipment recommendations
- Policy and decision support
  - Help decision makers select between options based on model results and supporting data
- Resource, budgeting and surge capacity estimation
- Scenario development/Training

Amplifying Information

Military Operational Organizations

Of the nine military operational organizations interviewed, seven responded to this question. Two additional uses for models were stressed. First, one organization indicated that models could be used in both planning and the Commander's assessment; in particular, models might prove useful when making long-term plans or plans for deliberate operations.

Three organizations noted that models could be used to increase planning utility for consequence management and natural and technological disasters.

Military Support Organizations

Twelve of the thirteen surveyed military support organizations responded to this question. The research organizations surveyed were particularly interested in additional model uses. Three organizations suggested that human response models might be used to help justify and prioritize research, including 1) research investment prioritization (which agents to focus on first); 2) requirements setting for research and development (i.e. which new drugs to pursue); and, 3) capturing the current research state and identifying gaps in research efforts (based on what's not in the models yet).

Similarly, three organizations noted that models might be useful to assist in risk assessment, suggesting that they could be used to facilitate both animal disease and food and waterborne disease risk assessment.

Civilian Organizations

Of the civilian organizations interviewed, eight responded to this question. Three suggested that validated, accredited models would provide significant support for policy and legislative decision making. Possible questions included the impact of stockpiling or widely distributing potassium iodide near nuclear power plants, the value of post-exposure vaccination, stay-at-home versus report-to-work policies, and the reporting time requirements that should be associated with medical surveillance and available detection systems.

Civilian organizations also believed that models could provide assistance with regard to resource allocation decisions (i.e. surge capacity), as well as helping answer questions regarding the impact of loss of resources. One organization suggested that models would be helpful to determine where resources would be lost in an emergency, but would also be useful in determining the impact of proposed hospital shutdowns before a disaster.

One civilian organization also stressed the importance of understanding and incorporating behavioral and compliance issues. They wanted to know more than the anticipated number of "Worried Well". They also wanted to understand the impacts of a population segment refusing vaccination. A second organization suggested that behavioral compliance was important so they could understand the impact on first responders and first receivers when some segment of the population is expected to self-quarantine.

NATO QUESTIONS

Allied users were asked one question with multiple sub-questions regarding their current AMedP-8 users and two regarding their uses of the document. Users were asked who current and potential future document users were, as well as what the document's primary purpose is for those users. They were then asked what other tasks the document is used for and what improvements might be made to the document.

NATO Question 1:

Which organizations use AmedP-8 now? For what purposes? Are there other potential users who would benefit from changes in the information provided, or if the structure and format of the STANAGs are expanded or changed?

Participants replied that current AMedP-8 users include "medical planners, with difficulty." Currently operators (i.e. J-3 staff) do not use the document, but respondents suggested that it could be a useful tool for planners (operational, medical, logistical, …) down to Brigade level. They also suggested that it might be useful for those in strategic and operational NBC defense roles.

NATO respondents stated two ways that they employ the document: 1) to estimate the quantity of medical countermeasures that should be procured and deployed; and 2) to determine demands on medical treatment facilities and the evacuation system.

NATO Question 2:
How is AmedP-8 used?

A single country responded to this question. The main use for AMedP-8 that they identified was to attempt to extrapolate/interpolate casualty estimates to current scenarios.

NATO Question 3:
Can AmedP-8 be revised to provide better support in these areas? If so, how? How is AmedP-8 used?

Respondents suggested several potential improvements for AMedP-8. These are listed below:

- Better definition of "casualty"
- New scenarios (discussed later)
- Products and tools supporting commanders decision making at all levels
- AMedP-8 should answer the following questions regarding casualty estimation:
    - How many people will be casualties?
    - When?
    - What kind of casualties?
    - What impact will alternative courses of action have to mitigate the operational and logistical impact of these casualties?
- User input of factors or "modifiers"

USERS & USES ASSESSMENT

Although NATO listed fewer users, the users that the countries suggested are included in the types of users suggested by U.S. interviews, as are the potential future users. The intended purposes for which the document is used are also among those identified by the U.S. community of users. Further, all users, both from the U.S. and NATO seemed to agree that significant improvements were need for existing human response/casualty estimation methods. Users agreed that the definitions of "casualty" need to be improved and that the primary purpose of any human response model is to estimate how many casualties, when they occur, what type they are, what requirements they generate, and how they change operational considerations.

E.4. INPUTS

SUB-TASK OBJECTIVE – INPUTS

The purpose of this section is to identify the input parameters which the user community feels must be considered, as well as those they anticipate having information about, for use in a CBRN Human Response Model.

U.S. QUESTIONS

Only two questions were asked to assess the inputs and parameters that users would consider important in the next generation of CBRN Human Response Models. Each question, however, had multiple parts. The first question pertained to specific inputs – both classes of inputs (i.e. agents, surveillance, demographics, etc) and specific types of inputs within each class (i.e. particular CBRN agents, types of medical countermeasures, etc) – and which of each users felt it necessary to include in the model. Participants were also given the opportunity to add additional classes and types of inputs that had not been considered by the interviewers.

For the second question, interviewers relied on answers provided in the Users & Uses section. For many of the types of uses that potential users named, participants were asked to identify the inputs and information that they anticipated actually knowing or assuming to be input while they were using the model. The questions and associated answers are shown below.

It should be noted that for these questions there are many areas of consensus, although the number of responses might not indicate the consensus wholly. In part because of interviewer style and the different ways questions were asked, and in part because of the individual participants themselves, some answers were repeated more often. In particular, this pertains to the agents of concern – biological agents were many organizations first response, and nuclear was seldom mentioned, but in follow-up conversations it became clear that nuclear was considered important as well. This information as well as any other additional or amplifying information, is included where available.

U.S. Question 1:
What parameters should the model address?

Of the thirty-two organizations/sites tallied, all thirty-two responded to, at least, some part of this question. Some answered all eight sub-questions, while others answered only one or

two parts. Therefore, for each individual sub-question, the number of responses will be provided separately.

U.S. Question 1A:
What parameters should the model address?

- **Agents?**

Twenty-eight of the organizations/sites tallied provided responses to this question. The general answer to this question is that users would like every possible agent included in the future human response models. Their more specific answers included biological agents including both warfare agents and emerging infectious diseases, chemical agents including toxic industrial chemicals (TICs), and radiological, nuclear and explosive threats.

Consensus

Interviewees agreed that biological, chemical, nuclear, radiological and explosive hazards should be included.

Twenty-two respondent organizations/sites mentioned that biological agents should be included. They suggested CDC Category A agents (6 of 22) and warfare agents (described generally or more specifically as those named in FM 3.41.8 or ITF-43) (6 of 22). More specifically, interviewees requested anthrax (6 of 22), pandemic influenza (6 of 22), smallpox (6 of 22), and others, including Botulinum toxin, tularemia, ricin, the viral hemorrhagic fevers (VHF), endemic diseases, emerging infectious diseases, and foodborne and waterborne threats.

With regards to chemical agents, twenty-two organizations/sites provided responses. Most organizations/sites agreed that chemical warfare agents (17 of 22), including nerve agents and mustard, and TICS (19 of 22) need to be modeled. Only eleven organizations/sites expressed an opinion regarding radiological hazards, but all eleven agreed that rad hazards should be included in future human response models.

Eight organizations/sites specifically mentioned the inclusion of nuclear threats. Seven of the eight agreed that nuclear hazards should be included, but disagreed on the type of nuclear threat. Respondents suggested improved nuclear devices (INDs), weapons, and attacks against nuclear facilities.

A summary list of the responses includes:

- Everything – all possible agents and hazards – should be included! (5 of 28)
- Biological agents (22 respondents)
    - CDC Category A agents (6 of 22)
    - DoD agents, including known weaponized, as well as those included in FM 3.41.8, ITF-43, and other DoD lists (6 of 22)
    - Specific weaponized agents

        - Anthrax (6 of 22)
        - Smallpox (6 of 22)
        - Botulinum Toxin (2 of 22)
        - Tularemia (3 of 22)
        - Ricin (3 of 22)
        - VHFs, including but not limited to Ebola and Marburg (4 of 22)
        - Naturally occurring and emerging infectious diseases (8 of 22)
            - Pandemic Flu (6 of 22)
            - Waterborne and Foodborne diseases, including but not limited to salmonella and cryptosporidium (3 of 22)
            - Others mentioned included SARS, burkholderia, pertussis, measles, etc.
        - Animal and crop diseases, including FMD, avian influenza, and others, were mentioned on a very limited basis
        - Military and civilian sectors both mentioned an interest in diseases for which military is vaccinated (they explained it could be useful information during civilian epidemics)
    - Chemical (22 respondents)
        - Warfare Agents
            - Nerve agents (17 of 22)
                - Many mentioned sarin specifically
            - Mustard agents (13 of 22)
            - Future chemical agents (6 of 22 specifically mentioned)
            - Cyanide
            - TICs
                - Chlorine
                - Phosgene
    - Nuclear (8 respondents)
            - Weapons
            - INDs
            - Facilities
    - Radiological (11 respondents)
            - RDDs
    - Explosives (8 respondents)
            - Fairly even split whether explosives should or should not be considered

Divergence

Military Operational Organizations

All ten of the surveyed military operational units responded to this question. As might be expected, their answers focused on known weaponized agents and battlefield threats, including nerve agents (9 of 10), mustard agents (9 of 10), nuclear (5 of 10), and biological agents (8 of 10). They also mentioned non-weaponized or asymmetric threats including TICs (8 of 10) and emerging and endemic diseases (6 of 10). Radiological hazards were recommended by only three of the ten.

It should be noted that three of the users recommended specifically excluding explosives, in particular because it was “not one of our primary concerns.” Further, users pointed out that any modeling should be tied to recommendations from the intelligence community, rather than have users determining the prioritization of agents on their own.

Military Support Organizations

Ten of the thirteen surveyed military support organizations responded to this question. The low response rate may be a result of the question having been asked less specifically (i.e. which inputs vice which agents) in the early interviews.

Perhaps as a function of the different roles they serve, the military support answers to this question achieved the least consensus. Four recommended the inclusion of chemical agents, including warfare agents, future agents, and TICs. Three mentioned biological agents. Only one specifically mentioned nuclear, radiological and explosives hazards.

It should be noted that three military support organizations stressed the importance of combined exposures – exposures resulting from more than one hazards applied to a population near-simulataneously. One also mentioned that future threats beyond chemical should be explored and considered for inclusion.

Civilian Organizations

Of the civilian organizations interviewed, eight responded to this question. Three specifically mentioned explosives – “Historically, it’s been assumed that civilian planners/responders knew about explosives and it’s not true. It’s not something we ever deal with.” Five agreed that radiological threats were a concern, but only two raised nuclear as a concern and those were a function of possible threats to nearby nuclear facilities. One specifically stated that INDs were not a concern for them.

With regards to chemical agents, five commented on warfare agents. Three raised concerns about sarin, ricin and poisons in general. Two, however, disagreed, stating, “If I said sarin, I’d be lying, because what are the chances of that happening?”

Biological agents and emerging infectious diseases posed a concern for all eight, but only one recommended the inclusion of all the agents on the CDC Category A agent list. Six specifically mentioned anthrax. Four mentioned smallpox. Several other agents were mentioned, including west nile, tularemia, dengue, equine encephalitis, pertussis, measles, hepatitis, VHF, rabies, plague, burkholderia, and SEB. Two noted that biological agents might be less of a concern than other weapons; one believed this was because the threat did not manifest immediately and so, therefore, might be less of a concern to emergency response organizations.

U.S. Question 1B:
What parameters should the model address? (continued)

- **Exposure routes?**

Twenty-four of thirty-two organizations/sites tallied provided responses to this question.

Consensus

Participants agreed that all applicable exposure routes, including inhalation (20 of 24), ingestion (19 of 24), dermal or cutaneous (16 of 24), and others should be included. While ocular exposure, secondary infection and human and animal vectors were less frequently mentioned, when asked specifically about these methods of transmission, respondents agreed that they should also be included where applicable.

- All applicable routes for each agent should be considered
- Generally, the following should be considered for modeling purposes:
  - Inhalation (20 of 24)
  - Ingestion (19 of 24)
  - Cutaneous (also referred to as percutaneous, contact, dermal, and transdermal) (16 of 24)
  - Human vectors
  - Animal vectors
  - Occular exposure

Divergence

Military Operational & Military Support Organizations

Eight of the ten military operational units and eight of the thirteen military support organizations surveyed responded to this question. Both military operational and military support expressed interest in combined routes of exposures, including trauma and radiological environment; multiple insults; simultaneous or consecutive radiological and biological insults. Two military support organizations also requested the incorporation of partial-body exposures.

Civilian Organizations

All nine civilian organizations responded to this question. One noted that civilian organizations might not be as familiar with the multiple possible exposure routes as other organizations, but was still interested in modeling the applicable routes. The remaining organizations concurred with all applicable routes, citing inhalation, contact, and foodborne and waterborne most commonly.

U.S. Question 1C:
What parameters should the model address? (continued)

- **Population at risk?**

Twenty-four of thirty-two organizations/sites tallied provided responses to this question. Population at Risk (PAR) was translated two specific ways – the size of the population to be modeled (i.e. is the organization modeling five or five million) and the anticipated changes in the population size (i.e. population in some cities doubles or more during business hours).

Consensus

There were limited areas of consensus with regards to this question. Respondents agreed that the population to be modeled might vary significantly in size “from 5 to 5 million.” Users also agreed that military and civilian populations should be differentiable or that other filters should be available for differentiating populations (16 of 24) to subgroup the PAR:

- US forces vs. indigenous or civilian population
- First responders, first receivers & “essential personnel”
- Transportation workers (civilian)

Divergence

Military Operational Organizations

Nine of the ten military operational units surveyed responded to this question. Two organizations recommended standard size units; “for military (Army) purposes, perhaps look at BCT-size force (4000) as basic size” or ships for the Navy. One unit also recommended using 1,000 strong forces as the basic unit for planning purposes. Two organizations wanted to be able to vary populations, either accounting for seasonal and event flow or regular dynamic movement.

All nine respondents agreed that the PAR should be able to be sub-grouped into military and civilian populations, to include co-located civilians, housing areas containing military and their civilian families, military and civilian populations in response areas, and military and indigenous populations in deployment theaters. Two organizations requested that additional filters be available to differentiate certain groups – for example, occupational structure, demographics, prioritization of personnel, and division by who does and who does not have personal protective equipment.

Military Support Organizations

Eight of the thirteen military support organizations responded to this question. The size of the requested population to be modeled varied from squad (2 of 8) to “limitless” (1 of 8). One also recommended allowing day vs. night population variations.

Three military support organizations suggested PAR filters to differentiate military and civilian personnel, particularly to account for susceptible populations.

Civilian Organization

Seven of nine civilian organizations responded to this question. There were no specific size modeling requirements stated, although participants did desire to use reasonable models of their own populations, including shifts from day to night populations (5 of 7), seasonal population increases (3 of 7) and special event population shifts (3 of 7). For example, one city noted that their school-year population increases significantly over their summer population as a function of the number of universities and colleges in the area. Another noted that special events can significantly increase the population and the risk simultaneously, so these increased populations need to be accounted for.

Although the civilian organizations did not request military/civilian filters, five suggested that population filters might be useful to account for first-responders, first-receivers, particular populations of concern, and other specialized personnel.

U.S. Question 1D:
What parameters should the model address? (continued)

- **Population demographics?**

Of the thirty-two organizations/sites tallied, twenty-five provided input to this question.

Consensus

Twenty-three of twenty-five organizations/sites agreed that demographics should be considered, but there was limited to no consensus among these user organizations as to which demographics should be included in future models.

Divergence

Military Operational Organizations

Eight of ten military operational units responded to this question. Seven suggested that demographics be included; one suggested that demographics were “not significant for response” and one stated that the utility of demographics would likely depend on the scenario. Of the seven that considered demographics useful, all seven wanted to include age “if relevant to the threat”, and six recommended gender. One pointed out that you “already know the crew composition – female/male and age.” Three organizations recommended that medical or health status be included (including pregnancy).

It should be noted that even within organizations, in part due to the multiple organizations and types of modelers represented in many discussions, there was disagreement. In

one organization, one modeler suggested that socio-economic status might be valuable to model while another replied, “I don’t perceive us getting involved in culture, language, socio-economic requirements.”

Military Support Organizations

Eight of the thirteen military support organizations responded to this question. Seven of the eight agreed that demographics were important, but two were quick to point out that the data might not exist to allow for demographic utility. One expressed lack of interest in demographic differentiation.

The demographics that these users considered important, however, varied widely. One wanted to model only healthy military populations. Two suggested that military vs. civilian might be enough breakdown. One user suggested racial and blood type breakdowns while a second stressed that the organization was “only interested in the most susceptible civilian populations.”

Civilian Organizations

All nine civilian organizations responded to this question, and all agreed that demographics should be included. Eight of the nine organizations indicated age as a primary demographic for consideration – elderly, young, etc. Six suggested that special needs should also be modeled as a demographic but definitions of special needs varied widely. Special needs incorporated everything from prison and homeless populations to immuno-compromised individuals to those who are mobility disabled or otherwise medically fragile. One organization suggested the following definition: “anyone who needs something to sustain life, either mechanical, human, or animal.”

Five suggested that language would be an interesting demographic. A different group of five suggested that access to transportation should be considered, but one disagreed, stating that it would be nice to have but not necessary.

Five suggested modeling compliance and behavior, including “worried well.” Three organizations also suggested accounting for health status and health care availability.

U.S. Question 1E:
What parameters should the model address? (continued)

- **Medical protection?**

Twenty-six of thirty-two organizations/sites responded to this question. The answers for this question actually considered both medical protection and personal protective equipment (PPE), based on user recommendations. For the purposes of this discussion medical protection was defined as medical countermeasures administered before the onset of symptoms to provide protection against illness or death, but also included such countermeasures as might be self-administered immediately following the onset of symptoms (i.e. Mk I kits for chemical nerve agent exposure).

Consensus

Twenty-six organizations/sites expressed an opinion regarding modeling of medical protection; twenty-two of the twenty-five agreed that (available) medical protection should be modeled; "users need the ability to account for medical protection, since it is part of the operational construct." Another explained saying, "immunization should be included since it changes the requirements and may change the supply." Vaccinations were specifically considered by nine of twenty-six, separate from anti-virals and antibiotics mentioned by five of twenty-six. Some detailed aspects of this were:

- Include immunizations troops already receive (noted specifically by Military – Operational)
- Include medicines available via the strategic national stockpile (SNS) and the metropolitan medical response system (MMRS) (noted specifically by Civilian)
- Efficacy is important and may need to vary by demographic
- Parameter may not be applicable to all users

Eleven organizations suggested that personal protective equipment also be considered as part of "protection." All users recommended masks, although the type of mask recommended varied by user community. Several users also recommended that all available types of PPE be included.

- MOPP Gear (Military Operational & Military Support users only)
- Gloves, goggles, and gowns, as well as other PPE (i.e. OSHA levels) (Civilian users only)

Divergence

Military Operational Organizations

Eight of ten military operational users responded to this question. Five specifically recommended that vaccines be modeled, especially with regards to the existing immunization status of an in-theater population. One organization suggested that there was value in identifying the differing immunization status between military and civilian populations in an area.

Six of the eight respondents suggested that PPE should also be modeled. Most recommended either all available or MOPP gear. One organization with some ties to civilian responders in its operating area requested OSHA levels, at least level A, equipment as well.

Two units also requested the inclusion of collective protection and other isolation methods (i.e. Circle William for ventilation isolation on ships).

Military Support Organizations

Eleven of the thirteen military support organizations responded to this question, and all eleven recommended the inclusion of medical protection. At least one organization requested that models be modifiable to account for "availability and new technology."

Two of the military support respondents specifically requested the inclusion of PPE – MOPP and masks.

Civilian Organizations

Seven civilian organizations expressed an opinion regarding the inclusion of medical protection. Five were in favor of its inclusion, while two suggested that for civilian populations medical protection may not be applicable – "We want to model what we actually have; not planning on doing what-if scenarios." Of the five in favor of its inclusion, two specifically requested that SNS and MMRS items be included. One other user requested both vaccination and potassium iodide be included. It was pointed out by one organization that if immunization is considered, they may also need a way to model those for whom the countermeasure is counterindicated.

Three organizations requested the inclusion of PPE, in particular for first responders and first receivers. They also suggested the inclusion of surgical masks, gloves, goggles, and gowns, as well as OSHA protection levels.

U.S. Question 1F:
What parameters should the model address? (continued)

- **Technical detection and/or surveillance?**

Twenty-one organizations/sites suggested that either technical detection and/or surveillance be modeled.

Consensus

Eighteen organizations/sites requested that technical detection be included. It may be useful to note that three disagreed as they did not consider it "a relevant parameter to the scope of human response models." Users believed that modeling different types of detection would

assist in decision-making with regards to understanding the impacts of time-delays, multiple tests, etc (two stated so specifically).

With regards to surveillance, twelve organizations/sites believed that surveillance results should be modeled. Two pointed out specifically that the speed of diagnosis should be included as well.

Amplifying Information

Military Operational Organizations

Five of the ten military operational units replied to this question. Three desired the inclusion of detection; one was unsure about its utility; one specifically did not require it to be included. The three that requested the capability did so to facilitate their own abilities to understand the systems' impacts. They wanted to be able to model specific detection systems, including the delay times and specificity.

With regards to surveillance, the four responding organizations were split evenly – two were in favor, two less so. One organization pointed out that syndromic may not actually be being done in the operational theaters, and so questioned whether the data would exist to support the efforts. One unit also requested the inclusion of veterinary surveillance.

Military Support Organizations

Nine of the thirteen military support organizations answered this question. Five believed that technical detection should be included, and one disagreed, explaining, "because the incident has happened as far as the model is concerned."

Four respondents requested the inclusion of syndromic surveillance; two pointed out that medical diagnosis time should also be included in the model.

Civilian Organizations

Six civilian organizations recommended the inclusion of technical detection. Two pointed out that the timing of detection and notification is extremely important to them; "technical detection has a time delay – it gets picked up by federal/state officials and only shared with the locals post-confirmation. It would be nice to prove that the time delay makes a difference in our ability to respond."

Six organizations also stated that having surveillance information in the model would be valuable and specifically mentioned the biowatch system and health alert networks as possible data sources. Two however noted problems, including the sheer volume of data to be processed –

“There is more data than can be handled” – and privacy concerns with regards to including real-time data in models.

U.S. Question 1G:
What parameters should the model address? (continued)

- **Treatment?**

Twenty organizations/sites expressed an opinion regarding the inclusion of treatment in a future human response model. Users varied in their desire for representation of treatment: which treatments; levels of treatment; need for efficacy data; and clinical outcomes.

Divergence

Military Operational Organizations

Seven of ten military operational users responded to this question, however, even within this group, there was disagreement with regards to whether treatment should be considered and, if so, which treatments. Five suggested that treatment be included; one was unclear but believed that inclusion might have utility; one did not suggest including treatment, pointing out that medical planners don’t calculate return-to-duty times since these times depend on the environment.

One recommended treatment be included to allow for calculation of logistics requirements and resources. Another organization disagreed internally; one user suggested that there was no need to include treatment briefs while another felt that both treatment and side effects should be included.

Military Support Organizations

Six of thirteen military support organizations provided responses to this question. Four were in favor of including treatment, from simple treatments to more invasive procedures. Two disagreed, arguing that “operators need to know the outcome without treatment for planning purposes.”

At least two organizations suggested that the utility of including treatment might be in allowing for the comparison of treatment options. One requested that (variable) treatment efficacy be included as well.

Civilian Organizations

Seven of nine civilian organizations expressed an opinion about modeling treatment. Three recommended at least including the items in the SNS. Users also recommended including potassium iodide, mark I kits, valium, cirpofloxacin and doxycycline, and possibly others.

These organizations (4 of 7) suggested that the value of inclusion rested in the ability to study the effects of varying treatments on disease spread for planning and selection purposes. Two organizations also wanted to model efficacy, side-effects and drug interactions. One pointed out, however, that this might be difficult due to lack of available data.

U.S. Question 1H:
What parameters should the model address? (continued)

- **Other?**

Several additional parameters were suggested for consideration, including, but not limited to, the following:

- Evacuation – want to be able to model the impacts of shelter-in-place vs. evacuation
- Local environmental factors (background or endemic levels)
- Pre-deployment issues vs. Attack vs.Post-deployment

U.S. Question 2:
What inputs would you like to specify?
For each specific use, what information are you likely to know to input into these models?

Of the twenty-eight organizations/sites that were asked this question, twenty provided responses. This question was not asked in the first four interviews. The intent of this question was to determine what information users were likely to know, have available or be willing to assume for different intended uses of the model. Although some additional uses were discussed in individual meetings, the three primary uses considered were: planning/training, event response, and retrospective analysis.

There were limited answers from the military support community to this question, in part because several were not asked this question. Therefore, the following results, showing the model uses and the input parameters that would likely be known or assumed are shown only for military operational and civilian groups.

It is worth noting that in some cases, such as medical protection or detection/surveillance, even when the input is known, it may be null. For example, if the civilian sector knows that there is no available detection, they know to input no detection into the model as an input or if there is no medical protection available for distribution immediately, then that input may similarly be null.

Scenario-Based Planning/Training

For scenario-based planning/training use, military operational users and civilian users believed that they would know the extent of the scenario they were aiming to develop. As a result, they would either know or assume the values for most of the required model inputs. The

civilian community suggested that, especially in planning situations, they would expect to vary the available detection, surveillance, and treatments, to allow for an analysis of alternatives. Table E.2 shows these groups' responses.

Table E.2. Military Operational & Civilian Organizations Inputs for Scenario-Based Planning/Training Uses

	Mil. Ops	Civilian
Agents	Yes (Assumed)	Yes (Assumed)
Exp. Routes	Probably	Yes (Assumed)
Pop. at Risk	Yes (Assumed)	Yes (Assumed)
Demographics	Yes (Assumed)	Yes (Assumed)
Med. Protection	Yes (Assumed)	Yes (Assumed)
Detection & Surv.	Yes (Assumed)	Want to vary
Treatment	Probably	Want to vary
Other	Perhaps	

Current Event Response

Current event response was defined as model use during or in response to an actual event. Current event response modeling might be used to estimate the numbers of casualties, the areas most likely to be affected, the necessary resources, and other items. It might also be used to evaluate how well a plan is working while the response is in progress – for example, do the estimated number of casualties match up with the reported numbers? Why or why not?

The problem with current event response use which many users noted is that in the initial stages of the event, there is not a lot of information available. Table E.3 shows the information that users anticipated knowing for input into any current event model. One military operational user suggested that they were likely to know the information only as their intelligence sources or CNN revealed it to them. Civilian users suggested that if they knew the symptoms they might be able to use additional resources and the model to make estimates of other model parameters, but much of their modeling ability relied on knowing the agent.

Table E.3. Military Operational & Civilian Organizations Inputs for Current Event Response

	Mil. Ops	Civilian
Agents	Not at first, may assume	Not at first, may assume, possibly w/i hours
Exp. Routes	Assumed	Possibly once agent is known
Pop. at Risk	Estimate (Mil/Civ)	Immediate at risk assessment, not all
Demographics	N/A, or Yes	Yes (working assumption)
Med. Protection	Yes, or may Assume	Not applicable
Detection & Surv.	Yes	Yes
Treatment	Yes, for Mil	Agent dependent, may make calculated guess
Other	Perhaps	Symptoms!

Retrospective Analysis

Two potential forms of retrospective analysis were discussed with users. The first method involved using a model to deconstruct an event and attempt to pinpoint an initial location or trace the timeline of an event; this application would be similar to an epidemiological or forensic investigation. Users suggested a second retrospective analysis application as well. Organizations suggested that a model might be used to evaluate lessons learned and conduct an analysis of alternatives for future lessons – what might have worked better? Would detection or surveillance have improved the response? Would a different medical treatment have lessened the casualty rate? These and other questions could potentially be answered using a model for retrospective analysis.

Because the analysis is done post-event, users anticipated knowing much of the information for the event. Their responses are shown below in Table 4.

Table E.4. Military Operational & Civilian Organizations Inputs for Retrospective Analysis

	Mil. Ops	Civilian
Agents	Yes	Yes
Exp. Routes	Yes	Yes
Pop. at Risk	Estimate (Mil/Civ)	Maybe
Demographics	N/A, or Yes	Yes
Med. Protection	Yes, or may Assume	Not applicable
Detection & Surv.	Yes	Yes
Treatment	Yes, for Mil	Yes
Other	Perhaps	Maybe

Amplifying Information

Additional recommendations were made by the user communities regarding the knowledge and information they would have for using the models and what uses they would choose to consider.

Military Support Organizations

Three military support organizations suggested that it might be useful to assume omniscient information for exploring various scenarios, planning, and training. They also pointed out that when modeling from afar, demographic information may or may not be known. They did suggest that information they did not know could successfully be assumed for modeling purposes and if sufficient information was not available, then perhaps the modeling efforts should not be pursued.

Civilian Organizations

Civilian respondents pointed out that, especially when the model was to be used for planning, policy, and resource estimation, the modelers need to be able to vary the inputs and the assumptions. This allows them to conduct an analysis of options to weigh the values of varying scenarios and to develop a range or estimates. One organization stressed that they could not assess the alternatives without the ability to change the inputs.

Civilian participants also suggested that agents, exposure routes, and treatment may all be based on best information-available guesses. At least two of the cities participating indicated that even when detection is available, their local governments are not currently notified until days later, after the agent is confirmed.

NATO QUESTIONS

Allied users were asked two questions regarding the scope of AMedP-8. Users were asked if the document would benefit from changes or expansion of the document's scope. The question and associated answers are shown below. Users were also told about proposed changes to the document, including the proposed inclusion of detection and medical protection, and asked to suggest other parameters that might be included. The question and associated answers are shown below.

It is important to note, though, that while users suggested and concurred with existing plans to expand AMedP-8, they wanted to be certain that such changes did not adversely impact the utility of the document. "Yes, expansion is needed, but not at the cost of complexity for the user. Whatever is done to improve AMedP-8 has to make it simpler for the planner and operator to use."

NATO Question 1:

Would AMedP-8 benefit from expansion in the scope of its content, by considering additional agents, delivery systems, or tactical scenarios? Plans exist to consider the effects of technical detection and medical protection, where applicable. Are there other considerations, such as treatment, that should be included?

Some users focused on particular scenarios in response to this question. New potential scenarios included:

- Single radiological or chemical IED in an open space or a closed space (closed room) against a squad, platoon, or a civilian group.
- The sabotage of an industrial area where toxic industrial chemicals (TIC) are stored (port facilities, industrial areas near military installations or civilian population centers)
- Chemicals that our current military filters do not take care of
- Ground burst nuclear weapon
- Survivability inside a protected shelter (hospital or command post) versus an unprotected shelter

NATO Question 2:

Plans exist to consider the effects of technical detection and medical protection, where applicable. Are there other considerations, such as treatment, that should be included?

Users concurred with the suggested inclusion of technical detection and medical protection. In some cases, users wanted to utilize AMedP-8 to estimate required resources (i.e. antidote kits needed for nerve or cyanide poisoning)

One user suggested that medical treatment might be included, but “only if it is in a section designated for use by medical personnel. The rest of the document must be usable by the personnel and operational staff.” At least one other suggested that both diagnosis and medical interventions, both countermeasures and treatment, might be included.

Additionally, one country suggested that the timing of treatment is critical following exposure: “resulting information may be useful for planning purposes (ie. if treatment is required at a Role 3 facility and there are a large number of casualties the outcome may be dependent upon the evacuation system, rather than the treatment).” Others agreed suggesting that reporting time for casualties should be modeled – for example, it would be useful to model “the numbers of respiratory casualties one would encounter within four hours of the event, and those that might report to the medical facility later.”

INPUTS ASSESSMENT

U.S. and NATO interviewees seemed to agree that any human response model should have a fairly significant scope, including a wide number and variation of agents, technical detection, medical protections, treatment, and possibly surveillance. The U.S. users, in part as a function of the additional questions they were asked, also concurred with the incorporation of multiple exposure routes, a discussion currently occurring within NATO, and improved information on populations at risk and population demographics as available and applicable.

E.5. OUTPUTS

SUB-TASK OBJECTIVE – OUTPUTS

This section identifies the outputs which the user community feels must be produced by future CBRN Human Response Models to effectively answer user questions and meet user needs.

U.S. QUESTIONS

Three questions were asked relating to desired attributes for human response model outputs. In all interviews, users were asked about the types of information that the models should be able to provide the user in the form of outputs. Users were also asked if they required confidence assessments to be presented as model outputs, and if they have a preference for how confidence should be expressed. After the first round of interviews, a third question was added, addressing the desired level of flexibility in defining ranges, or bins, within output categories, particularly the casualty category, since the definition of casualty may vary based on the type of user. The questions and associated answers are discussed below.

U.S. Question 1:
What information should the models output?

Of the thirty-two organizations/sites tallied, thirty provided an answer to this question.

Consensus

Based on the answers provided to this question by 30 organizations, there was consensus (30 of 30) that the models should output the numbers and time phase of persons affected in various ways (casualties, fatalities, “worried well,” etc.) to meet the needs of various types of users (medical planners, operational planners, responders, etc.); furthermore, there was wide agreement (21 of 30) that the models should provide the status of casualties over time, grouped into various status categories (type of injury or illness, symptoms, etc.). On the other hand, interviewees did not agree that treatment should be modeled (see Section V).

The consensus answers to question 1 regarding outputs are outlined below.

- The models should output the number and time phase of:
  - Persons who did not exhibit symptoms of the effect (i.e., remained well): 5 of 30
  - Casualties (ill or injured) (30 of 30)
  - Fatalities: 9 of 30

- The model should also report:
  - Number of “Worried well:” 8 of 30
  - Number of Psychological casualties: 8 of 30
- The model output should report the status of casualties over time, grouped by various categories: 21 of 30
  - Type of injury or illness: 12 of 30
  - Severity of Illness: 5 of 30
  - Symptoms/ systemic effects: 11 of 30
  - Clinical outcome (without treatment): 5 of 30

Therefore, all thirty organizations agreed that the models should provide numbers of casualties and when those casualties occur over time, regardless of how casualties are defined. Both military and civilian user communities desired the number and time phase of fatalities, persons who did not exhibit symptoms of the illness or injury, persons who were “worried well,” and persons who were psychological casualties (to include psychosomatic casualties). Both military and civilian communities indicated that model outputs should include the status of casualties over time grouped according to type of injury or illness, severity of illness, symptoms or systemic effects, and performance level.

Divergence

On the other hand, interviewees did not agree that treatment should be modeled. Organizations that desired treatment as a model attribute (14 of 30) requested additional outputs, including numbers and time phase of persons requiring treatment (6 of 30) and resulting resource requirements (8 of 30). Thus, regarding treatment-related outputs, users desired the number of persons requiring treatment and how the number varies over time (5 of 30); the number of people requiring treatment grouped by patient condition code (for military use) or triage levels (for civilian use), allowing estimation of the types of treatment required (9 of 30); the post-treatment clinical outcome or fate of patients (3 of 30); the number of patients, categorized by length of care required (4 of 30); and resources required for treatment (10 of 30).

Military Operational Organizations

Certain desired attributes were unique to the military community. Of the ten military operational organizations who responded to this question, one was also interested in the total number of persons exposed (1 of 10). Three organizations were interested in the geographic locations of casualties (3 of 10), in addition to numbers of casualties and the time phase of their emergence. And, two military operational organizations were interested in the fate or outcome of untreated casualties (2 of 10). The military operational community was the only one of the three communities interested in persons who recover from injury or illness and become eligible to return to duty, or RTDs (2 of 10). The military operational community was also the primary

community interested in seeing performance levels of casualties as outputs (5 of 10). One organization interviewed asked for the inclusion of contamination assessment for fatalities (1 of 10), and another desired help in determination of evacuation requirements (1 of 10).

Four of ten military operational organizations desired treatment-related outputs (4 of 10). Some members of the military operational community requested that the model outputs provide the number of people who seek treatment (1 of 10), identify critical components within required resources (1 of 10), help determine the resources available (beds, staff, etc.) (1 of 10).

Divergent answers provided by the military operation community are summarized below.

- Models should output the number of persons exposed (1 of 10)
- Models should output the geographic locations of casualties (3 of 10)
- The models should output the number and time phase of recovered individuals (RTDs) (2 of 10)
- Models should output performance levels for casualties (5 of 10)
- Include contamination assessment of fatalities (1 of 10)
- Determination of evacuation requirements (1 of 10)
- Treatment-related outputs desired (4 of 10)
  - Number of people who seek treatment (1 of 10)
  - Identification of critical components within required resources (1 of 10)
  - Determination of resources available(1 of 10)

Military Support Organizations

Within this group, eleven organizations responded. Of those, one was interested in the total number of persons exposed (1 of 11), in addition to the various other outputs listed above. One organization was interested in the geographic locations of casualties (1 of 11), in addition to numbers of casualties and the time phase of their emergence. And, three military operational organizations were interested in the fate or outcome of untreated casualties (3 of 11). Only the military support community was interested in also seeing the total number of persons located in the exposure area (1 of 11), and one was interested in performance levels for casualties (1 of 11).

In addition to the outputs listed in the consensus section above, the military operational community also requested that the model outputs provide information on anticipated behavior, particularly the number of people who seek treatment (1 of 11), include detailed clinical data, such as biomarkers, in addition to signs and symptoms (1 of 11), and for contagious diseases, provide the number of people belonging to various cohorts (infectious, removed, etc.) at various time points (1 of 11). Three military support organizations desired treatment-related outputs (3 of 11). One organization suggested including the following output categories: statutory casualties, prompt vs. kinetic casualties, long-term casualties, and psychological casualties (1 of 11). There was also a suggestion to further subdivide the outputs according to demographics within each

output category (1 of 11). Several organizations stressed that models produce results which are actionable.

Divergent answers provided by the military support community are summarized below.

Models should output:

- Total number of persons exposed (1 of 11)
- Geographic locations of casualties (1 of 11)
- Performance levels for casualties (1 of 11)
- Fate or outcome of untreated casualties (3 of 11)
- Total number of persons located in exposure area (1 of 11)
- Number of people belonging to various cohorts for infectious agents (1 of 11)
- Number of people who seek treatment (1 of 11)
- Detailed clinical data, such as biomarkers (1 of 11)

Civilian Organizations

Of the nine civilian organizations that responded to this question, one was interested in reporting of performance levels, defined as a measure of the ability for a particular type of worker to continue doing his job (1 of 9) after being adversely affected (a casualty); this information would help the user estimate when to replace workers, based on a performance evaluation rather than signs and symptoms. One organization was interested in the mobility status of people over time (walking, need to be carried, will self-report to medical facility, will call ambulance) in order to plan for transportation and first-responder requirements (1 of 9). Seven organizations were interested in treatment-related outputs (7 of 9), rendering this a point of consensus within the civilian community members interviewed for this study.

In addition to the outputs listed in the consensus section above, the civilian community requested that the models recommend courses of action for particular time periods after an event (1 of 9), appropriate personal protective equipment (1 of 9), and the most effective prophylaxis choices (1 of 9) for a given scenario. The models should also take into account and report on the behavioral responses of a population, particularly absenteeism expectations (due to sickness, fear, caring for the sick, etc.) (1 of 9). One organization desired that models help them identify the subset of their population most at-risk for injury, illness and/or death for a given scenario (1 of 9).

Divergent answers provided by the civilian community are summarized below.

Models should output:

- Mobility status (walks out on own, needs assistance, etc.) over time (1 of 9)
- Models should output performance levels for casualties (1 of 9)
- Recommended courses of action after event (1 of 9)

- Recommended personal protective equipment (1 of 9)
- Recommended prophylaxis options (1 of 9)
- Anticipated population behavioral responses, particularly absenteeism (1 of 9)
- At-risk subset of population (1 of 9)

U.S. Question 2:

Do you want to be able to define the output ranges? Do you want to be able to change them?

Because this question was added after the first interview, only thirty-one of the thirty-two organizations/sites tallied were asked this question. Moreover, during the first few interviews, this question was asked as "Should output definitions be flexible for the user?" Of the thirty-one organizations that were asked the question, twenty-one provided an answer.

Consensus

Generally, interviewees want the option to define the boundaries of output ranges, for the various categories of outputs, and particularly for casualties; yet, they also want predefined default ranges. Many interviewees recognized that situation of scarce resources and/or mass casualty events may require alternate definitions of casualty. Interviewees also recognized that different users set a different threshold for the level of injury or illness that may constitute a casualty. They wanted to be able to set the threshold according to their definition of casualty. In addition, they want the ability to filter outputs according to population type (civilian, military, medical staff, first-responders, etc.). The following bullets summarize the answers to Question 2:

- Users would like to define the boundaries of output ranges for various categories of outputs (17 of 21)
- Users would like to have default or predefined output ranges for various output categories (12 of 21)
- Users want to be able to filter the outputs for the following (6 of 21)
  - Medical staff (2 of 21)
  - Civilian population (2 of 21)
  - Military population (2 of 21)
  - Population demographics (1 of 21)
  - First responders (2 of 21)

Amplifying Information

Military Operational Organizations

Of the seven military operational organizations that responded to this question, six wanted to define the boundaries of output ranges (6 of 7), and six wanted to have the option of choosing predefined output ranges, or defaults (6 of 7). Many interviewees requested that outputs should have as many defaults as possible. One organization suggested that the performance (mission ineffectiveness) outputs may be stratified into severe, mild, and moderate

ineffectiveness. Three organizations wanted the ability to apply filters to outputs; one wanted to be able to distinguish first responders from the remainder of the population (1 of 7).

The military operational community was unique in its desire to filter or separate civilian and military populations in the outputs (2 of 7).

Military Support Organizations

Of the nine military support organizations that responded to this question, six wanted the ability to define the boundaries of output ranges (6 of 9), and 5 wanted the option of choosing among predefined output ranges (5 of 9). One organization suggested that stratification (ranges) of outputs (such as casualty or illness categories) should be based on treatment requirements; the number of strata should depend on the illness and the potential user. One military support organization desired the ability to filter the outputs to distinguish the medical staff from the general population (1 of 9).

Civilian Organizations

All five civilian organizations that responded to this question requested the ability to define the boundaries of output ranges (5 of 5); one civilian organization also wanted the option of predefined output ranges (1 of 5). Two organizations wanted the ability to filter the outputs (2 of 5); they wanted to filter the outputs to distinguish the medical staff and first responders from the general population, as well as filter outputs according to various population demographics.

In addition to the outputs listed in the consensus section above, one interviewee among the civilian community wanted to filter outputs by risk categories, including displaced populations and special needs populations.

U.S. Question 3:
Would you like to see risk/ hazard confidence assessments? How would you like to see confidence expressed?

Of the thirty-two organizations/sites tallied, twenty-nine provided an answer to this question.

Consensus

Based on the answers provided to this question by twenty-nine organizations/sites, there was consensus on the importance of having confidence in the models and seeing that confidence expressed with quantitative and/or qualitative methods. Some interviewees wanted confidence assessments available even when they did not plan to communicate this information to decision-makers. Interviewees agreed that outputs should convey an appropriate level of fidelity. They also wanted the models to report the significant factors contributing to the confidence

assessment, such as confidence in the underlying data, confidence in its applicability to the scenario, confidence in inputs, etc. Most users felt that confidence assessments would have long-term implications for decision-making and accountability.

On the other hand, interviewees did not agree on how confidence should be expressed. Most interviewees suggested using a quantitative expression of confidence with traditional confidence intervals (levels) and their upper and lower boundaries (limits). However, some suggested that a qualitative expression of confidence would be sufficient; for example express confidence in results by low, moderate, or high, with explanatory bullets flagging elements that could be improved to improve the confidence. Others felt that both quantitative and qualitative expressions should be included, to suit the needs and preferences of different users. Several organizations stressed the importance of flagging the key parameters that contribute to the uncertainty, informing the user that confidence can be improved by obtaining more information in those areas. Several organizations suggested that outputs include applicability statements explaining the limitations of the model (and, therefore, outputs) and/or describing circumstances under which the confidence changes on no longer applies.

The following bullets summarize the answers to question 3.

Of the organizations who expressed an opinion regarding confidence assessments

- Yes, confidence assessments should be provided (27 of 29)
- Confidence assessments may not be necessary (2 of 29)
- Quantitative expression of confidence should be used (Confidence levels and their limits) (20 of 29)
- Qualitative expression of confidence should be used (20 of 29)
  - Color-coding (red, yellow, green) (3 of 29)
  - Qualitative bins (high, medium, low) (1 of 29)
  - Subject matter expert (SME) assessment (expressed qualitatively) (2 of 29)

Other requests related to confidence assessment:

- Applicability statements, including caveats for circumstances under which the confidence changes or no longer applies (2 of 29)
- Appropriate fidelity represented in outputs (2 of 29)
- Significant contributing factors to confidence (or lack thereof) (8 of 29)
- Avoid the use of color-coding (2 of 29)

Therefore, a majority of organizations interviewed agreed that the models should provide confidence assessments as part of the outputs. Most organization preferred a quantitative expression of confidence, although many acknowledged that this may not be meaningful in some cases due to the complex nature of these types of models.

Amplifying Information

Military Operational Organizations

Of the eight military operational organizations who responded to this question, one responded that confidence intervals would be dependent upon data and assumptions; therefore, they would need the ability to determine whether model inputs are accurate or accepted. While commanders may not ask for confidence assessment, interviewees felt that some commanders will ask how comfortable the analyst is with the model results. However, interviewees from another organization did not think that confidence assessment would be necessary; given the assumption that the best data available is being used in the models, they would rather base their confidence in model outputs on the field experience of their leaders.

Military Support Organizations

Within this group, twelve organizations responded. In addition to the outputs listed above, one organization stated that uncertainty/risk needs to be couched in terms of risk templates, instead of numerically-based. One organization stated that the confidence assessment should not combine errors from different contributing factors, since users may be interested in the worst case event or may want to represent the most vulnerable populations in their model runs. Another organization recommended using standard confidence measurement systems, in particular, the standard deviation index (SDI), which they believe most laboratories know how to use.

Civilian Organizations

Of the nine civilian organizations that responded to this question, most were interested in understanding the sources and caveats or limitations of the underlying data and model assumptions, in order to have any confidence in the results. They also wanted to understand where the confidence changes or no longer applies, particularly for various demographics. For example, they wanted to learn from the model that a particular output is most applicable to young, healthy Caucasian males but can be translated to the general population with a specified decrease in confidence.

Additional Considerations

Most interviewees realized that modeling is based on assumptions, so there is significant potential for the introduction of error. Users want the best possible model that science can provide at this time, and, as one interviewee stated, “hopefully we will never find out if we were wrong.”

NATO QUESTIONS

Allied users were not asked about outputs and confidence assessments for AMedP-8. However, it should be noted that in conversations with Allied Nations, several nations are concerned with the confidence of outputs, as the current AMedP-8 does not provide confidence information for the outputs. At least one nation expressed a distinct preference for the inclusion of confidence levels for the outputs of AMedP-8.

E.6. TIME

SUB-TASK OBJECTIVE – TIME

This section deals with the roles and significance of the time parameter in CBRN Human Response Models. It identifies the times, both as input and output, which the user community feels should be represented within CBRN Human Response Models in order to effectively answer user questions and meet user needs.

U.S. QUESTIONS

Three questions were asked relating to the time parameter. Users were asked whether time should be a factor or parameter in human response models. If so, should time be considered as an input parameter? Should time be considered as an output parameter? The questions and associated answers are shown below.

U.S. Question 1:
Should time be a factor in the model?

Of the thirty-two organizations/sites tallied, thirty expressed an opinion or provided an answer to this question.

Consensus

All interviewees who answered this question unanimously agreed that time should be considered as a parameter in CBRN human response models (30 of 30). Many pointed out that most existing human response models are inadequate because they do not consider the time dimension; often these models simply report numbers of casualties and fatalities without estimating when they occur.

U.S. Question 2:
Should time be considered as an input?

- **What times are important to you as the user?**

Because this question was added after the first round of interviews, only twenty-six of the thirty-two organizations/sites tallied were asked this question. Of the twenty-six organizations/sites that were asked the question, fourteen provided an answer.

Consensus

All interviewed organizations that answered this question felt that time was an important input parameter for human response models (14 of 14). Interviewees wanted to include various time-based inputs, including time of exposure (1 of 14), time of providing medical interventions (4 of 14), time of patient presentation to the medical system (2 of 14), and time of symptom onset (1 of 14). Many interviewees felt that the granularity of input times (minutes, hours, days, etc.) should be appropriate to the agent (6 of 14). Some users would like to determine the scope of outputs by inputting information regarding response at various time points, particularly medical response. They also would like to use the models to study time dependencies for providing care, receiving casualties, providing more supplies, etc, and how these times would change based on agent.

U.S. Question 3:
Should time be considered as an output?

- **What time intervals should outputs be divided into? (Minutes? Hours? Days? Months?)**
- **What time periods are you concerned with for observing casualties (Acute? Latent? Chronic? Protracted?)**

Since this question was added after the first round of interviews, only twenty-nine of the thirty-two organizations/sites tallied were asked this question. Of these twenty-nine organizations/sites, twenty-nine provided answers to the question in the first sub-bullet; twenty-one provided answers to the question in the second sub-bullet. During several interviews the bulleted questions were replaced by the following question: "If so, what time should be considered."

Consensus

All twenty-nine organizations/sites that provided an answer to question 3 agreed that time should be considered as a model output parameter. Regarding the time intervals or granularity that should be reported, answers ranged from minutes (5 of 29) to hours (5 of 29) to days (3 of 29). While interviewees did not agree on the smallest time unit for reporting, they generally agreed that outputs should be reported over increasing time intervals (7 of 29). Many interviewees suggested reporting minutes or hours initially, then days, then weeks or months (6 of 29). There was also consensus on the agent-dependent nature of time intervals (12 of 29). Many interviewees noted that nuclear and chemical agent effects occur rapidly and, therefore, results should be reported on the scale of minutes (at least for some period of time) for these agents; however, most biological agent effects occur and progress more slowly and may be reported on a time scale of days. Regarding the maximum length of time desired for reporting

outputs, answers (13 of 29) also varied among interviewees. Suggestions for this attribute depended on the responsibilities or missions of highest concern. For military missions, the length of the operation and the evacuation policy were sighted often as determining factors for the maximum reporting time of concern.

Most interviewees expressed the desire to consider one or more effects periods for observing casualties (21 of 29). Of those who provided an answer, almost all agreed that acute effects should be considered and reported in the models (19 of 21). Most interviewees were also interested in delayed or latent effects (11 of 21) and chronic or long-term effects (14 of 21). Some interviewees (4 of 21) felt that all applicable effects periods should be considered for the agents that are modeled. A few interviewees noted that methods currently exist for calculating chronic effects from low-level exposures, and while these should be investigated, they should not constitute a high priority for CBRN human response models.

Amplifying Information

Military Operational Organizations

According to the responses of the military operational community, various endpoints determine the maximum length of time of interest for reporting outputs. The issue of time and time intervals will likely be mission-dependent. The end of the timeline will vary by user type and will generally be the time when response is no longer necessary. Operators may be concerned with casualties until they are evacuated. Contingency planners may want to look further ahead in time, out to 30-60 days. For deliberate planning, the timeline of interest may extend even further. Strategic planners will want to be able to estimate casualties until the individual has either returned to duty or been discharged. For personnel replacement, planners would need to observe casualties out to 6 months. In summary, tactical users are interested in the fate of casualties up to the time points of death, evacuation, or return to duty. For operational planners, the timeline of concern corresponds to the length of the operation. For strategic planners, the timeline of interest ends at recovery or discharge.

Within the military operational community, interviewees were primarily concerned with acute effects and, secondarily, delayed or latent effects, both occurring on the time scale of the operation; however, they wanted to be able to observe both short-term and long-term effects as needed for various types of planning and decision-making.

Civilian Organizations

The civilian organizations interviewed in this project indicated that public health departments and the government in general are concerned with the long-term health effects

resulting from CBRN events. In particular, they plan for and manage long-term care for individuals with chronic illness. As one interviewee described, “the length of illness and the requirements for long-term care impact the viability and recovery of the city, as well as the long-term viability of the healthcare system.” Therefore, there was general consensus within this community that human response models need to represent the entire time period of the human response: acute, latent, and chronic effects.

NATO QUESTIONS

Allied users were not specifically asked about the time parameter for AMedP-8.

E.7. METHODOLOGY

SUB-TASK OBJECTIVE – METHODOLOGY

This section identifies methodologies which the user community feels must be included in a CBRN Human Response Model or which should be excluded from future models.

U.S. QUESTIONS

Two questions were asked relating to preferred methodology. Users were asked which methodology(ies) should be incorporated into the human response model. After the first round of interviews, a second question was added, based on interviewee inputs, addressing the desired level of model transparency. The questions and associated answers are shown below.

U.S. Question 1:

What methodology should be used in the human response model? Do you have a preference or recommendation?

- **Probit? Performance-based? Toxic load? Other?**

Of the thirty-two organizations/sites tallied, twenty-one expressed an opinion or provided an answer to this question.

Consensus

Many respondents (8 out of 21 organizations/sites) expressed the point that users often do not know enough about the specific methodologies to choose one or another. As a result, users (7 of 21) recommended using the methodology most appropriate to the agent, population, response, and level of detail required for modeling. Additionally, interviewees (7 of 21) indicated that multiple methodologies may be required to cover all of the agents of consideration. Several of the remaining interviewees did not specify a particular methodology, but rather expressed characteristics of the methodology that they would like to see included. These answers are noted below; the included sub-bullets provide amplifying information provided by single interviewee organizations, except where otherwise noted.

- The methodology must include what is appropriate for the agent, population and response being modeled (7 of 21)
  - Time dimension of human response must be considered (2 of 21)
  - Duration of exposure should be considered as appropriate and as information is available to support modeling (4 of 21)
  - Accepted values should be incorporated into the models and should not be alterable by users (2 of 21)

    - Nature and severity of signs and symptoms should be captured
    - Capability should be represented
- One model does not fit all agents, thus multiple methodologies might be required (7 of 21)
    - Availability of data should drive selection of model for any given scenario
        - It may be difficult or impossible to dig out original data from unpublished research
    - Preference should be given to methodologies that are accredited, validated and defensible
    - Some interviewees (3 of 21) requested that all available methodologies be incorporated into the final model, allowing the final user to select the preferred methodology

For those interviewees that did select a preferred methodology, three of twenty-one expressed a preference for probit models. Three organizations expressly said no to probit methodology because it does not provide time phased-results. Three of twenty-one (two of those who also expressed interest in probit methodology) preferred toxic load be incorporated where data and information was available. An additional organization pointed out that while the toxic load may be better, they are currently invested in using probit data internally.

Divergence

Military Operational Organizations

Of the seven military operational organizations who responded to this question, only two expressed a preference for particular methodologies; one recommended probit and toxic load, while a second suggested using statistical analysis methodology.

Generally, interviewees either didn't know enough about the models to express a particular opinion (3 of 7) or wanted "all available" methodologies incorporated (2 of 7).

Military Support Organizations

Within this group, seven of the organizations responded. Of those, four expressed a distinct preference for a particular methodology – probit (2 of 7) or toxic load (2 of 7) – while three expressed a preference to not include a particular methodology – probit (3 of 7) – because interviewees wanted to ensure that results could be expressed over time. One member organization in this group also expressed the desire to have all competing methodologies incorporated into the model.

Civilian Organizations

Of the civilian organizations interviewed, seven responded to this question. Three recommended using the best available model for the agent; one suggested that the best available models were likely military models altered to incorporate civilian data. Two organizations did not express a preference – "Methodology doesn't much matter if it gives us the answer."

One member of this group expressed a preference for toxic load and probit models. A second suggested that “SME best guess could be used to determine underlying methodology, if no other basis exists.”

U.S. Question 2:
How much insight would you require into the underlying methodology? Underlying data?

- **Completely transparent (algorithms)? Black box?**

Because this question was added based on initial interviewee response, only twenty-nine of the thirty-two organizations/sites tallied were asked this question. Of those twenty-nine organizations/sites, twenty-six expressed an opinion or provided an answer to this question.

Consensus

Half of the interviewed organizations/sites (13 of 26) desired complete transparency of the final models, stating “as much information as possible,” “want to kick the tires,” and “the more we can get the better.” Slightly less than half of the interviewed organizations (11 of 26), including some of those who expressed a desire for complete transparency, requested a black box model for at least some of the users if not all. Responses between these two extremes included detailed documentation of the assumptions and variables (10 of 26) and incorporation of references and insight into methodology and data sources (17 of 26).

Although these responses indicate that respondents disagreed over the level of transparency required within the models, these discrepancies may be easily remediable through thorough documentation. Respondents (10 of 26) indicated that transparency may be achieved through documentation – the algorithms, parameters, inputs, etc. may be recorded in a supplementary document but should be provided.

Interviewed organizations also stressed that efforts to make models transparent should not complicate the model; one organization pointed out, “The people who can understand and want to implement the methodology aren’t likely to be the ones who have to translate the implications.”

Further, interviewed organizations (3 of 26) stressed that models should be “blessed by an authoritative organization” and “scientifically defensible, valid, and reliable.”

These answers are summarized below; additional, amplifying information is provided in the sub-bullets.

- Model use should not be complicated by efforts at transparency
- Transparency should be provided (by documentation) (13 of 26)
  - *This would be accessed to differing degrees by different users.*
    - Operational users (none to moderate)

        - Staff support (none to moderate)
        - Policy users (none to moderate)
        - Clinical users (moderate to complete)
        - Civilian planners (moderate to complete)
        - Reach back / Research (complete)
    - Documentation should be comprehensive (10 of 26)
        - Methodological process (including algorithms and parameters)
        - Underlying assumptions and variables
        - Vulnerabilities (strengths and weaknesses)
        - Data references
- Methodology must be scientifically defensible, valid, reliable (3 of 26)

Additional Considerations

One point that several respondents raised is the need for multiple levels of models – black box models for the common/warfighter/emergency responder user with increasing levels of complexity and transparency for medical users, researchers, etc. At the common user level, the concern is for ease of use. At the research level, respondents indicated the desire to be able to "manipulate or at least see and understand the assumptions."

Further, respondents indicated that the model needs to be flexible and alterable, so that as better information and methodologies become available they may be incorporated.

NATO QUESTIONS

Allied users were asked one question regarding AMedP-8 methodology. Users were asked if the document would benefit from changes or expansion of the methodologies currently employed.

Question 1:

Would AmedP-8 benefit from expansion or changes to its approach and methodology? Currently AmedP-8 provides worst case casualty estimates and plans exist to provide a more flexible range of estimates for the specific combination of agents, delivery systems, and tactical scenarios now considered. Are there other areas where users desire greater flexibility?

In this case, interviewees focused less on particular methodologies – i.e. probit, toxic load, etc – and more on the methods by which data is represented. Interviewed Allied Nations expressed the following desired changes:

- Incorporate medical countermeasures through the use of modifiers/factors reflecting differences in susceptibility, protective gear, posture, MCM, …
- Allow for a selection such as "Worst Case" "Most Probable Impact" "Center of Unit" "Forward Unit" or "Rear Echelon."
- Provide additional flexibility in severity of attack, delivery systems, and unit arrangements.

- Consider an effects based output representation – large numbers of rapid casualties are a burden to medical services and warfighters

It should be noted that in conversations with Allied Nations, one nation expressed a distinct preference for the inclusion of toxic load models. In addition, Nations encouraged the incorporation of multiple methodologies and the use of methodologies appropriate to the agents being modeled. Further, Nations have been adamant in their desire for models that are based on scientifically defensible data. They also expressed a desire for thorough documentation of the models, the assumptions and the data sources.

METHODOLOGY ASSESSMENT

U.S. and NATO interviewees seemed to agree that particular methodologies are less important than selecting the appropriate methodology for the agent. Both sets of respondents indicated that model transparency may be achieved through documentation, and that, while not specifically a model methodology assertion, the data incorporated into the models must be the scientifically published and defensible.

E.8. APPLICATION/TOOL

SUB-TASK OBJECTIVE – APPLICATION/TOOL

This section deals with the roles and significance of the application/tool in CBRN Human Response Models. It identifies platforms, programs, formats, and support which the user community feels is necessary for the CBRN Human Response Models in order to effectively answer user questions and meet user needs.

U.S. QUESTIONS

Five questions were asked relating to application/tool use. Users were asked: (1) What platform(s) should run this application? (2) What interface should this application/tool use? (3) What program(s) should the tool be compatible with? (4) What level of training would you expect to receive for this tool/model? (5) What level of support would your activity require for this tool/model?

U.S. Question 1:
What platform(s) should run this application?

Of the 32 organizations/sites tallied, 20 expressed an opinion or provided an answer to this question.

Consensus

Interviewees agreed that the choice of platform matters, with different platforms chosen to meet the needs of different users: in general, program and platform must meet compatibility requirements. For example, some communities will require web-based platforms, while others will require those that stand-alone. The PC is a common and available hardware for the platform, and some interviewees suggested that results be exportable to personal digital assistants (PDAs).

U.S. Question 2:
What interface should this application/tool use?

Of the 32 organizations/sites tallied, 12 expressed an opinion or provided an answer to this question.

Consensus

The consensus among interviewees was that a graphical user interface (GUI) was preferable. The GUI should be as simple as possible, while maintaining functionality: interviewees agreed

that a user-friendly tool was required. Additionally, the GUI would ideally incorporate default and recommended settings, provide the ability to select alternative inputs (options) and to input user data, and include guidance for and ability to input specific information. Links to data sources, references, user-support (or "help") and other requested supporting details were also recommended.

U.S. Question 3:
What program(s) should the tool be compatible with?

Of the thirty-two organizations/sites tallied, twenty-four expressed an opinion or provided an answer to this question.

Consensus

Interviewees agreed that the tool should have exportable inputs and outputs. In the special case of current event response, the model should take real-time data inputs and update continuously. Moreover, the tool should be compatible with a number of commonly allied programs. Those interviewees cited included: the Windows Office suite (Excel, Word, Access, PowerPoint, etc.); geospatial-referencing tools, such as GIS, Arcview, and ESRI; database tools, such as Oracle and Access; plume models, such NARAC, Cameo, Aloha; and resource-estimation tools, such as JMAT.

Amplifying Information

Military Operational Organizations

The interviewees from the military and operation community requested particular programs that diverged from those requested by the civilian community. These programs included the Critical Infrastructure Tool, ABCs (Army Battle Command systems), and TRADOC Battle Command System

Civilian Organizations

The civilian organizations interviewed in this project indicated that public health departments and the government in general would like confidentiality controls in place so that local inputs can be included. Particular programs that would require the tool be compatible included: emergency operations programs, such as WebEOC and ETeam; and surveillance tools, such as BioWatch and Health Alert Network (HAN).

U.S. Question 4:
What level of training would you expect to receive for this tool/model?

Of the thirty-two organizations/sites tallied, eighteen expressed an opinion or provided an answer to this question.

Consensus

Users clearly recognized that training is required and should be ongoing. Furthermore, there was a widespread consensus that model usage is understood to be an expendable skill, so refresher training must be available: interviewees pointed out that roll-outs of previous models have failed due to system complexity and incomplete training. It was widely agreed, moreover, that training should vary by user-level.

In addition, it was suggest that there would be train-the-trainer and expert training either onsite or offsite; classroom training for general users; online or computer-based tutorial for refresher training; and an internal wizard to provide additional assistance. Multiple training modalities—including web-based, computer-based and classroom modalities—should ideally exist, and training should focus on intended uses, such as aiding in useful scenario development, assessing assumptions, results, etc., and taking action to correct questionable results.

U.S. Question 5:
What level of support would your activity require for this tool/model?

Of the thirty-two organizations/sites tallied, sixteen expressed an opinion or provided an answer to this question.

Consensus

All respondents expected some support. Support would ideally include around-the-clock reach back capability that would give assistance both running the model and assessing results. Certain interviewees claimed that off-hours assistance would be vital since, "disasters never happen during business hours" A web-based help desk or chat capability would also be beneficial. One proposed idea included potential off-site modelers to aid in extreme situations. A potential need also exists for periodic on-site support to help work through a particular drill and/or exercise.

NATO QUESTIONS

NATO users were asked several questions regarding the structure and format of AMedP-8. Their answers are depicted below.

NATO Question 1:
Would AMedP-8 benefit from changes in its structure and format?

Users felt that AMedP-8 would benefit significantly from changes in structure and format. They provided the following answers:

- The current format is un-workable and needs to be distilled down to what the user actually needs
- More explanation on assumptions and methodology
- Perhaps a trefoil of products:

  1. A text document containing an accurate description of the modeling approach, the tactical scenarios including the maneuver elements, a few exemplary tables, and a list of references from which the data and underlying assumptions were derived.

  2. A software tool to generate casualty estimates in tables accessible to open source software (locally classified).

  3. A training tool enabling potential users getting acquainted with the product without being required to have access to a secure computer system.
- A tabular format/slide-rule/radiac wheel/e-version—any format that makes the tool more user friendly would improve acceptance of the product.
- Include a graphical format – in particular, for plotting the changes in numbers of casualties over a period of time.

NATO Question 2:

Would users prefer an electronic tool to assist navigation and specification of cases of interest? Would users prefer to have a methodology available that would allow them to generate their own casualty estimation?

Users felt that AMedP-8 would benefit significantly from the use of an electronic tool. They also wanted to have the methodology available for interested and capable users to generate their own casualty estimates. NATO users provided the following answers:

- Electronic tools would assist in navigating through the document
- Electronic tool should allow the user to vary assumptions and generate estimates
- Output should be exportable / transferable to a spreadsheet program
- Note: this format may be useful to the staff officer in higher formation but probably not to the commander on the ground.

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Appendix F

ACRONYMS

ACRONYMS

ABCs	Army Battle Command Systems
ACO	NATO Supreme Allied Command, Operational
ACT	NATO Supreme Allied Command, Transformation
AFIOH	Air Force Institute for Operational Health
AFMOA	Air Force Medical Operations Agency
AFMS	Air Force Medical Service
AFRL	Air Force Research Lab
AFRRI	Armed Forces Radiobiology Research Institute
AFSG	Air Force Surgeon General
AFSGR	Air Force Surgeon General Reserve
AHRQ	Agency for Healthcare Research and Quality
AMEDDC&S	United States Army Medical Center and School
AMed P-8	Allied Medical Publication-8
ANGRC	Air National Guard Readiness Center
ARA	Applied Research Associates
ARCENT	United States Army Central Command
ARNORTH	United States Army North
ASBP	Armed Services Blood Program
BPHC	Boston Public Health Commission
BUMED	Navy Bureau of Medicine
BWIC	Biological Warning and Incident Characterization
C2F	Command 2nd Fleet
CAMEO	Computer-aided Management of Emergency Operations

CAN	Canada
CASS	Center for AMEDD Strategic Studies
CATS	Combined Arms Training System
CBRN	Chemical, Biological, Radiological and Nuclear
CBRNMWG	Chemical, Biological, Radiological and Nuclear Medical Working Group
CCID	Coordinating Center for Infectious Diseases
CDC	Centers for Disease Control and Prevention
CENTCOM	United States Central Command
CHPPM	United States Army Center for Health Promotion and Preventive Medicine
CHRNEM	Combined Human Response Nuclear Effects Model
COGH	Coordinating Office for Global Health, CDC
COMPACFLT	Commander, United States Pacific Fleet
COTPER	Coordinating Office for Terrorism Preparedness and Emergency Response, CDC
CUD	Common User Database
DARPA	Defense Threat Reduction Agency
DCDD	Directorate of Combat and Directive Development
DHS	Department of Homeland Security
DICE/IDP	Defense Nuclear Agency's Improved Casualty Estimation/ Intermediate Dose Program
DMH	Department of Mental Health
DMSB	Defense Medical Standardization Board
DOD	Department of Defense
DOEHRS	Defense Occupational and Environmental Health Readiness System
DOJ	Department of Justice
DOT	Department of Transportation
DSNS	Division of Strategic National Stockpile

DTRA	Defense Threat Reduction Agency
ECBC	Edgewood Chemical & Biological Center
EMS	Emergency Medical Services
EOP	Executive Office of the President
EOS	Epidemic Outbreak Surveillance
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FFC	Fleet Forces Command
FRMAC	Federal Radiological Monitoring and Assessment Center
GBR	Great Britain
GEIS	DOD Global Emerging Infections System
GIS	Geographic Information System
GUI	Graphical User Interface
HAN	Health Alert Network
HHS	Department of Health and Human Services
HPAC	Hazard Prediction and Assessment Capability
IAC	Incident Analysis Cell
IDA	Institute for Defense Analyses
IND	Improvised Nuclear Device
IND	Investigation New Drug
JEM	Joint Effects Modeling
JMAT	Joint Medical Analysis Tool
JFCOM	United States Joint Forces Command
JOEF	Joint Operational Effects Federation

JRO-CBRN	Joint Requirements Office – Chemical, Biological, Radiological & Nuclear
JTF-CS	Joint Task Force – Civil Support
JWARN	Joint Warning and Reporting Network
KAMI	Knowledge Acquisition Management Instrument
LA	Los Angeles
LANL	Los Alamos National Lab
LAWA	Los Angeles World Airports
LMI	Logistic Management Institute
MARFORCOM	US Marine Corps Forces Command
MAT	Medical Analysis Tool
MEDCOM	United States Medical Command
MMRS	Metropolitan Medical Response System
MSS	Medical Surveillance System
NARAC	National Atmospheric Release Advisory Capability
NATO	North Atlantic Treaty Organization
NAVMEDCENSD	Naval Medical Center San Diego
NBC CREST	Nuclear, Chemical & Biological Casualty & Resource Estimation Support Tool
NBCMedWG	NATO NBC Medical Working Group
NBIS	National Biological Information System
NCID	National Center for Infectious Disease
NECC	Net-Enabled Command Capability
NEHC	Navy Environmental Health Center
NEPMU-5	Navy Environmental and Preventive Medicine Unit 5
NHRC	Naval Health Research Center
NHTSA	National Highway Traffic Safety Administration
NIOSH	National Institute for Occupational Safety and Health

NIPR	Unclassified but Sensitive Internet Protocol Router Network
NLD	The Netherlands
NCMO	Navy Material Cataloging Office
NMCSD	Naval Medical Center San Diego
NORAD	North American Aerospace Defense Command
NORTHCOM	United States Northern Command
NSW	Naval Special Warfare Command
NY/NJ INTEL	New York/New Jersey Intelligence Agency
NYC	New York City
NYPD	New York City Police Department
OEM	Office of Emergency Management
OPHEP	Office of Public Health Emergency Preparedness
OTSG	Office of the Army Surgeon General
PACOM	United States Pacific Command
PAR	Population at Risk
PC	Personal Computer
PDA	Personal Digital Assistant
PH	Public Health
PHMSA	Pipeline and Hazardous Materials Safety Administration
PSD	Particle Size Distribution
RDD	Radiological Dispersal Device
RIVGRU ONE	River Group One
RSO	Regional Supply Office
RTD	Return to Duty
S&T	Science and Technology
SABERS	System to Automate the Benchmark Rate Structure
SD	San Diego

SIPR	Secret Internet Protocol Router Network
SMEs	Subject Matter Experts
SNS	Strategic National Stockpile
SOCPAC	Special Operations Command, Pacific
SOF	Special Operations Forces
STRATCOM	United States Strategic Command
SWMI	Surface Warfare Medicine Institute
TICs	Toxic Industrial Chemicals
TIMs	Toxic Industrial Materials
TRADOC	United Stated Army Training and Doctrine Command
USA	United States Army
USA	United States of America
USACHPPM	United States Army Center for Health Promotion and Preventive Medicine
USAF	United States Air Force
USAFSAM	United States Air Force School of Aerospace Medicine
USAMRICD	United States Army Medical Research Institute of Chemical Defense
USAMRIID	United States Army Medical Research Institute for Infectious Diseases
USANCA	United States Army Nuclear and Chemical Agency
USARPAC	United States Army Pacific Command
USCG	United States Coast Guard
USFORSCOM	United States Army Forces Command
USMC	United States Marine Corps
USN	United States Navy
USUHS	Uniformed Services University of the Health Sciences
VA	Department of Veterans Affairs
VLSTRACK	Vapor, Liquid, Solid Tracking Model
WHO	World Health Organization

Appendix G

REFERENCES

REFERENCES

Christenson, W.M. et.al. 2002. *The Incubator Process: Methodology*, IDA D-2779. Alexandria, VA: Institute for Defense Analyses.

North Atlantic Treaty Organization (NATO). Military Agency for Standardization, Standardization Agreement: Medical Planning Guide of NBC Battle Casualties, Nuclear, AMedP-8, Volume I, Ratification Draft.

-------- . Military Agency for Standardization, Standardization Agreement: Medical Planning Guide of NBC Battle Casualties, Biological, AMedP-8, Volume II, Ratification Draft.

-------- . Military Agency for Standardization, Standardization Agreement: Medical Planning Guide of NBC Battle Casualties, Chemical, AMedP-8(A), Volume III, Ratification Draft.

-------- . NATO Handbook on the Medical Aspects of NBC Defensive Operations, AMedP-6(B).

Sowadsky, Rick. 1999. "Are You a 'Worried Well' Person?" *The Body: The Complete HIV/AIDS Resource*. Website. http://www.thebody.com/content/art2306.html.

Williams, Phillip L., Robert C. James, & Stephen M. ed. 2000. *Principles of Toxicology: Environmental and Industrial Applications*, *Second Edition*. New York City: John Wiley & Sons, Inc.

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14. ABSTRACT
A human response model, also known as a casualty estimation model, is usually one component of a larger suite of models. For our purposes, the human response model is used to estimate the number of people who may be expected to require medical treatment, as well as the number of anticipated fatalities due to the insult over time resulting in personnel exposed to some event involving Chemical, Biological, Radiological, or Nuclear (CBRN) agents (or influenza). There are currently several different models and methodologies for estimating human response. Thus, the goal of a coordinated human response model is to provide a single model that can be used by planners and responders at all levels (both military and civilian), so that every user can expect to get a similar answer for the same question. This paper summarizes the model attributes – users and uses, inputs, outputs, time, and methodology – desired by a sample user community representing both the military and civilian sectors at all levels and proposes next steps for developing the requirements for a consolidated human response model.

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Modeling, model attributes, human response, casualty estimation, chemical warfare, biological warfare, nuclear warfare

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